Chapter 4. ENVIRONMENTAL SETTINGS

4.1 Project Setting

The structure and function of the ecosystems contained within the project area is the focus of this chapter. Following a brief overview, the important elements that make up these marine ecosystems will be presented in detail. These components include the climate, oceanography, habitats and the communities and species that inhabit them, and the various human activities that can influence these coastal marine ecosystems.

The project area encompasses a region generally known as the northern Channel Islands. From west to east these islands are San Miguel, Santa Rosa, Santa Cruz, and Anacapa. Santa Barbara Islands lies to the southeast of this island chain. The northern Channel Islands are part of a larger ecological region known as the Southern California Bight (SCB). The Southern California Bight extends from Point Conception to Punta Banda, south of Ensenada, Baja California, Mexico (Dailey et al. 1993; Reisch et al. 1993). The SCB is formed by a physically defined transition in the California coastline wherein the north-south trending coast begins to trend east-west.

The waters that move around these islands combine warm and cool currents to create exceptional habitat and breeding ground for many marine species. Giant kelp forests are home to numerous populations of fish and invertebrates. Seventy-five percent of the kelp ecosystems of the Southern California Bight exist within the nearshore waters of the Channel Islands. Eelgrass (*Zostera spp.*) beds found within the project area provide habitat for a variety of invertebrates and small fishes. Eelgrass beds are considered to be one of the most productive habitat types found on soft-bottom substrate, as they provide food production and physical structure for the biological community and act as a nursery for many fish species. Every year over 27 species of whales and dolphins visit or inhabit the Channel Islands region, including blue whales, humpback whales, and sei whales. Several species of marine mammals use the shores of the Channel Islands and rocky outcroppings as haul-outs and rookeries. Additionally, seabird diversity is great within the project area, and many important breeding grounds and colonies can be found.

The habitats and biological communities of the Southern California Bight are influenced by dynamic relationships among climate, ecology, and oceanography (e.g., currents) (Leet et al. 2001). The SCB provides essential nutrients and marine habitats for a range of species and organisms. Submarine canyons, ridges, basins and seamounts provide unique deep water habitats within the region. The basins provide habitats for a significant number of mid-water and benthic deep-sea fishes near the Channel Islands, whereas nearshore areas provide habitats for kelp and seagrass communities. The nearshore geology of the project area provides of a variety of bottom types, including soft sediments and rocky bottoms. Hard-substrates environments, such as the rocky intertidal, shallow subtidal reefs, and deep rock reefs, are a key component of the high productivity found within the project area. Due to linkages among ecosysems, the impacts of ecosystem dynamics contained within the project area extend to interactions with species in the greater Eastern Pacific Ocean.

The project area is host to numerous human activities that interact with the natural environment. Human activities occurring in and near the project area include oil and gas development, vessel transportation within the busy shipping lanes in nearby waters, non-point source pollution, commercial and recreational fishing, and consumptive diving (free and SCUBA). Nonconsumptive recreational activities are also important, including kayaking, non-consumptive diving (free and SCUBA), surfing, and sailing.

4.2 Physical Environment

4.2.1 Climate and Meteorology

The northern Channel Islands are influenced by a Mediterranean climate, which is characterized by mild winters, when most rainfall occurs, and warm, dry summers. Continental processes also influence the climate of the project area. The climate is dominated by a strong and persistent high-pressure system that frequently lies off the Pacific coast (generally referred to as the Pacific High). The Pacific High shifts northward or southward in response to seasonal changes or the presence of cyclonic storms. In its usual position to the west of Santa Barbara, the Pacific High produces an elevated temperature inversion. Coastal areas are characterized by early morning southeast winds, which generally shift to northwest later in the day. Transport of cool, humid marine air onshore by these northwest winds causes frequent fog and low clouds near the coast, particularly during night and morning hours in the late spring and early summer months.

The sea breeze is typically northwesterly throughout the year; however, local topography causes variations. During summer months, these northwesterly winds are stronger and persist later into the night. Southerly and easterly winds occur frequently in winter and occasionally in the summer. Topography plays a significant role in direction and speed of winds in the Channel Islands. During the day, the sea breeze (from sea to land) is dominant. Winds reverse in the evening as the air mass over the coastal land cools, becomes heavier, and flows down the coastal mountains and mountain valleys back toward the ocean as land breezes (from land to sea). The terrain around Point Conception, combined with the change in orientation of the coastline from north-south to east-west, can cause counterclockwise circulation (eddies) to form east of the point. These eddies fluctuate from time to time and place to place, leading to highly variable winds along the southern coastal strip, including the project area. Point Conception also marks the change in the prevailing surface winds from northwesterly to southwesterly. During the fall and winter months, the region is subject to Santa Ana winds, which are warm, dry, strong, and gusty winds that blow northeasterly from the inland desert basins through the mountain valleys and out to sea. Wind speeds associated with Santa Ana conditions are generally 15 to 20 miles per hour (mph) although they can reach speeds in excess of 60 mph. "Sundowner" winds are a local phenomenon on the coastal strip below the canyons. Similar to Santa Ana conditions, warm, gusty winds blow sometimes with great intensity down canyons toward the sea. However in contrast, these winds are local and caused by land-sea and diurnal temperature variations.

Water and air quality is not only a coastal issue, but an offshore issue with coastal inputs reaching as far as the Channel Islands. Water and air pollution are cross-medium and transboundary, which means the pollution exceeds the spatial scale of the project area. Pollution south of Point Mugu (outside the project area) is carried north to the northern Southern California Bight by currents, such as the Southern California Counter Current. More than 80 percent of the anthropogenic inputs from industrial discharges, urban runoff, and ocean dumping (point source pollution) enters the project area from Los Angeles

County. Most of the non-point source pollution enters the project area through freshwater inputs from within the project area, contributing some of the greatest amounts of nutrients and contamination.

4.2.2 Air Quality

In general, atmospheric stability is a primary factor affecting air quality, and this is true for the project area. Atmospheric stability regulates the amount of air exchange both horizontally and vertically. Restricted mixing (that is, a high degree of stability) and low wind speeds are generally associated with higher pollutant concentrations. These conditions are typically related to temperature inversions that cap the pollutants emitted below or within them. An inversion is characterized by a layer of warmer air above the cooler air mass near the ground, preventing pollutants in the lower air mass from dispersing upward beyond the inversion "lid." This results in higher concentration of pollutants trapped below the inversion.

In light-wind conditions, air quality in Santa Barbara County can be impacted by temperature inversions and the trapping of pollutants and pollutant precursors. During Santa Ana conditions, pollutants emitted in Santa Barbara, Ventura County, and the South Coast Air Basin (SCAB, which includes the Los Angeles region) are moved out to sea. Some of these pollutants may then impact the Channel Islands. These pollutants can then move back onshore to Santa Barbara County (via the Santa Barbara Channel) in what is called a “post Santa Ana condition.” They may also become entrained in offshore winds and get transported farther south before coming onshore.

The criteria pollutants for which the National Ambient Air Quality Standards (NAAQS) have been established include sulfur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), ozone (O_3), particulate matter 10 microns or less in diameter (PM_{10}), reactive organic compounds (ROCs), and lead (Pb). The California Ambient Air Quality Standards (CAAQS) are generally more stringent than the NAAQS and have incorporated additional standards for sulfates (SO_4), hydrogen sulfide (H_2S), vinyl chloride, and visibility-reducing particulate matter. When there is a lack of data for the U.S. EPA to define an area, the area is designated as “unclassified” and treated as an attainment area until proven otherwise.

Santa Barbara County is in attainment (meets the standard) for all air quality standards except the Federal and State O_3 standards and the State standard for PM_{10}. The following text addresses Santa Barbara County’s air quality nonattainment for these two pollutants and the environmental and source factors contributing to this nonattainment status. As the closest source for pollutants to the Channel Islands, Santa Barbara County represents the maximum possible levels for the Islands.

<u>Ozone Nonattainment</u>

Ozone is not produced directly by any pollutant source, rather it is formed by a reaction between NO_x and ROCs in the presence of sunlight. Ozone concentrations are generally highest during the summer months and coincide with atmospheric inversions. At their maximum, O_3 concentrations tend to be regionally distributed. This is due to the homogeneous dispersion of the precursor emissions in the atmosphere. Hence, when an inversion occurs, the mixing of the precursor pollutants is within a much smaller volume of air. Santa Barbara is in “serious” nonattainment as a result of missing the 31 December 1996 deadline to meet the Federal O_3 standard, regardless of the overall trend of improved air quality of the Santa Barbara Region. In 1998, Santa Barbara County reported 2 days during which the NAAQS standard was exceeded at various monitoring stations throughout the county; however, the more stringent CAAQS standard was exceeded on 15 days.

PM_{10} Nonattainment

PM_{10} is produced either by direct emission of particulates from a source or by formation of aerosols as a result of chemical reactions in the atmosphere involving precursor pollutants. The sources of PM_{10} can also be categorized as natural (geogenic) or resulting from human activity (anthropogenic). The largest source of PM_{10} emissions in Santa Barbara county is entrained paved road dust. Other sources of PM_{10} emissions include dust from construction and demolition, agricultural activities, entrained road dust from unpaved roads, natural dust, and particulate matter released during combustion. As previously mentioned, Santa Barbara County exceeds the 24-hour and annual standards CAAQS for PM_{10}. Exceedances of the annual standard predominantly occur at the downtown Santa Maria monitoring station. Exceedances of the 24-hour standard are more widespread across the county, although they do not occur as frequently.

4.2.3 Water Quality

Marine and coastal water quality is impacted by two types of pollution, the difference between the two being determined by the source of input into the natural system. Non-point source pollution , or polluted runoff, most often comes from a more ambiguous source, or a broader area, usually in the form of runoff from a variety of land uses such as agriculture, urban, and industrial operations. Point source pollution can be traced to a clearly discernible source, usually industrial or municipal facilities such as sewage treatment plants, oil refineries or power plants. In general the Channel Islands are removed from water pollution sources by their distance from shore. Several potential pollution sources exist in the surrounding region and are discussed here.

Natural Oil Seeps

Natural oil seeps are found offshore in the Southern California Bight from Point Conception to Huntington Beach. The largest concentration of seeps is in the Santa Barbara Channel area, adjacent to the project area (Wilkinson 1972). In the area of “Coal Oil Point”, Santa Barbara County, seepage has been estimated to occur at a rate of 50 to 70 barrels of oil per day (Wilkinson 1972). In general, the oil released from seeps is moved by currents and wind to the shoreline, either on the mainland coast, or the Channel Islands. Studies have shown no lasting detrimental effect on the marine environment (Wilkinson 1972). The constant release of natural oil, however, makes it difficult to determine when human activities have resulted in a spill (Wilson pers. comm.).

Non Point Source Pollution

Non point source pollution (NSP) does not originate from individual, identifiable sources, but rather results when rainfall or irrigation runs over the land or through the ground, picks up pollutants, and carries them to streams, rivers wetlands, coastal waters, and during heavy rainfall, offshore. Agriculture, forestry, grazing, urban runoff, development and construction, physical changes to stream beds, and habitat degradation are all sources of NSP pollution. The most common NSP pollutants are sediments and nutrients such as fertilizers. Other non point source pollutants in the project area may include:

- herbicides and insecticides from urban and agricultural runoff;
- oil, grease, toxic chemicals, and heavy metals from urban runoff and energy production;
- bacteria, viruses, and nutrients from livestock, pet wastes and faulty septic systems;
- accidental spills of fuels and other hazardous materials:
- air pollutants that settle out of the atmosphere onto the ocean.

Though the biological impacts of inorganic and organic inputs on marine ecosystems and living resources is understood, there is a paucity of published data and information on this subject. Significant human-induced disturbances to the watershed, such as agriculture, urbanization and industrialization may be a major contributor to non-point source pollution impacting coastal and marine systems in the project area. Potential impacts to the ecosystem include: lowered photosynthesis and oxygen levels, introduction of disease, disturbance to spawning and nursery areas, loss of food sources (trophic disruption) and habitats, chemical disturbances, destruction of benthic biota, resuspension of fine sediments and interference with filter feeding and respiratory functions of marine organisms.

<u>Coastal Runoff</u>

The annual precipitation in Santa Barbara averaged 44.6 cm from 1987 to 1992 (Page et al. 1995), with 92 percent falling from November to April. Floods of coastal watersheds result from intense storms; typically, there is a very short time lag (several hours) from rainfall to runoff owing to the steep terrain, intensity of rainfall and thin soil cover (Mertes et al. 1998). Hickey (2000b) estimated that the volume of fresh water discharged in the ocean during a typical five-day flood in the Santa Barbara Channel would create a 6.5-foot (2-meter) high column of water over an area of about 3.8 to 38 square miles (10 to 100 square kilometers).

During winter storms, the four large rivers that discharge into the project area (Santa Clara, Ventura, Santa Maria, and Santa Ynez rivers) are capable of producing large discharge plumes that can affect the Santa Barbara Channel (Hickey 2000b). The discharge from a single major storm event can be much larger than the average annual discharge. During the upwelling conditions that follow major floods, the plume from the Santa Clara and Ventura Rivers can surround Anacapa Island (Hickey 2000b). Upwelling conditions also form a plume from the discharges of the Santa Maria and Santa Ynez Rivers that extends southward past Point Conception and enters that channel from the west (Hickey 2000b). The upwelling that follows major storm events is very effective at moving fine sediments away from coastal river mouths and out toward the Channel Islands (Hickey 2000b). This material is derived from mainland river watersheds, which include agricultural lands and urban areas. Pollutants such as pesticides, fertilizers, PCBs, and oil are rapidly transferred from their point of origin to coastal marshes or the ocean. (Hickey 2000b), at times reaching the project area.

Island Runoff

There are also a number of watersheds located in the four northern Channel Islands. The intensity of grazing on Santa Cruz Island has resulted in loss in vegetation cover of watersheds and has changed the natural sediment transport processes (Brumbaugh 1980). Recent reductions in the sheep population have resulted in some recovery of vegetation, but no study has been completed to determine if there has been a reduction of sediment erosion.

Point Source Pollution

A total of twenty-eight discrete sources of point pollution to the coastal waters between Point Magu northward to Point Sal have been identified and they come from: sewage, power plants, industrial waste, and storm water outfalls (considered point sources by Section 402(p) of the Clean Water Act). Anderson et al. (1993) also identify 178 discrete point sources of contaminant and nutrient input to the Southern California Bight from Point Conception to the Mexican Border.

The suburbanization of the Los Angeles Basin and coastal regions of Orange and San Diego counties have a direct impact on the marine environment of project area. Approximately 82 percent of municipal wastewater effluents, 95 percent of the discrete industrial wastes, 70 percent of the power plant-returned cooling waters and 71 percent of the surface runoff in southern California enter the coastal waters in the area located between Point Dume and San Mateo Point (Anderson et al. 1993). Since this area also includes about 70 percent of the total southern California population, the majority of contaminants from aerial fallout also probably originate south of the project area boundary.

The following examples of point source pollution provide a general overview or characterization of some of the types of water quality impacts that the project area may face.

Oil Platforms

Twenty-one platforms and approximately 180 miles of associated pipelines are located in the waters between Point Mugu and Point Sal. A total of 19 platforms are in Federal waters and 2 are in State waters. There is currently one artificial island (Rincon Island) and one offshore drilling and production platform (Platform Holly) in State waters. There are 79 remaining Outer Continental Leases (OCS) (Federal), all off the coast of southern California in San Luis Obispo, Santa Barbara, Ventura and Los Angeles counties. A total of 43 are developed leases, and 39 of the developed leases are in the project area. The developed leases are producing a total of 100,000 barrels of oil and over 200 million cubic feet of gas per day.

Effluent discharge is only permitted from oil and gas platforms located in Federal waters; no discharges are permitted from facilities located in State waters. While all platforms have the potential to discharge drilling muds and cuttings, only Exxon’s Platform Heritage is conducting a drilling program and at present is using both water and oil based drilling muds for these extended reach wells. Since oil base muds cannot be discharged, the amount of water-base muds being discharged from these wells is probably less than for the other occasional wells that have been drilled at the other platforms during the last 6 to 8 years. A total of 10 of the 16 platforms discharge produced water, while all platforms discharge deck drainage, treated sewage, well completion and workover fluids, and other effluents (MMS 2001).

A project conducted by the Southern California Coastal Water Research Project (SCCWRP) found that although offshore oil production in the region increased by a factor of six from 1935 to 1991, oil platforms operating in Federal waters in 1990 were a relatively minor source of contaminants to the coastal ocean. The mass emissions of drilling wastes were 9 percent of the mass emissions of suspended solids discharged from the four largest municipal wastewater treatment facilities in southern California. The mass emissions of contaminants from produced water from oil platforms were less than one percent of the combined emissions for the same constituents from the four largest municipal facilities. The total mass emissions from the offshore platforms were low because most drilling and sanitary wastes generated at offshore platforms in 1990 were sent to onshore facilities for processing.

In addition to the possibility of oil spills and accidental gas releases, a wide variety of pollutant discharges are normally associated with oil and gas development including: drill cuttings and mud, sewage and trash, formation waters, marine corrosion products and air pollutants. The possible water quality impacts and associated marine resource impacts from oil and gas development include destruction of benthic biota, resuspension of fine sediments, interference with filter feeding and respiratory functions of marine organisms, loss of food sources and habitats, and lowered oxygen and photosynthesis levels.

Needless to say, the largest concerns about oil and gas development and the potentially devastating impacts on water quality, sensitive habitats and living and non-living marine resources, come from the threat of offshore oil well blowouts, pipeline leaks, oil tanker spills, decommissioning of platforms and natural seepage, rather than the day to day activity of extracting oil and gas itself.

Given the level of offshore oil and gas development in the Santa Barbara Channel, the Polycyclic Aromatic Hydrocarbons (PAH) pollutants may be of particular concern. PAH pollutants are organic compounds that are among the heaviest molecular fraction of petroleum hydrocarbons. Because they are not very soluble in water and tend to accumulate as particulates in aqautic systems, they can become persistent as well as concentrated within the aquatic food chain. Commonly found at high levels in estuarine and marine sediments near industrial centers, they serve as a continual source of contamination for biotic communities. PAHs are released through fossil fuel combustion, asphalt production, leaching of creosote oil, and spills of oil, gasoline, diesel, and other petroleum products.

The effects of large oil spills on giant kelp beds (*Macrocystis pyrifera*) have been documented twice along the western Pacific coast; once during 1957 when a small tanker, the Tampico, spilled a load of mineral oil in a cove along Baja California; the other during the 1969 offshore well blow-out and spill in the Santa Barbara Channel (Foster and Schiel 1985). North et al. (1964) studied the Tampico spill and noted that there was massive mortality of invertebrates, including sea urchins, in the cove. Damage to giant kelp was not obvious and within five months of the spill, vegetation in the cove was increasing and juvenile giant kelp began to develop. Presumably, the diesel oil had killed sea urchins that had been maintaining the bottom. Once the urchins were killed, giant kelp and other species of algae began to develop (North et al. 1964). Giant kelp plants that recruited following the loss of sea urchins produced canopy in the cove, approximately 18 months after the spill.

Crude oil from the 1969 Santa Barbara spill polluted a large portion of the mainland coast, and many of the Channel Islands (Foster et al. 1971). Assessment of the effects of the spill was complicated by record storms and rainfall that occurred at the same time as the spill. There was little damage to the giant kelp beds, even though considerable quantities of crude oil fouled the surface canopies (Foster et al. 1971). The partially weathered crude oil appeared to stay on the surface of the water and did not stick to the fronds of the giant kelp.

Besides the direct effects from oil spills on giant kelp, there are documented negative effects on kelp from substances used in oil spill clean up operations. The surfactant-based oil dispersant, Corexit 9554 has been shown to have acutely toxic effects on the early life stages of giant kelp (Singer et.al. 1995).

There are also extensive natural gas and oil seeps that occur near beds of giant kelp near Santa Barbara (Mertz 1959). These seeps produce continuous oil slicks on the surface of the water and even visible tar mounds on the bottom within kelp beds (Spies and Davis 1979). The natural seeps appear to cause no visible damage to nearby giant kelp beds, since extensive canopies regularly develop in these beds when oceanographic conditions are good for growth (Wilson pers. comm.).

<u>Power Plants</u>

There are currently two power plants, the Ocean Vista Power Generation Company and Ormond Beach Generating Station, discharging into the ocean in Ventura County. Anderson et al. (1993) show that power plants discharge 10 times more volume than municipal wastewater treatment plants. Overall, industrial inputs to the coastal waters in the region are small compared to other point sources. The concern with power plants continues to be: toxicity of effluents and biological impacts on living marine resources; sediment input and destruction of benthic biota, interference with filter feeding and respiratory functions of marine organisms and loss of food sources and habitats; and loss of living marine resources somewhat from impingement on intake screens and mainly from entrainment. Effluent toxicity is not limited to chemical toxins and includes thermal toxicity of heated water effluent.

<u>Ocean Dumping</u>

There are no ocean disposal or active dumping sites within the project area. Discharge and disposal of most materials are specifically prohibited within the project area, under the regulations designating the Sanctuary. There are inactive chemical dump sites located in the vicinity of Santa Lucia Bank and south of Santa Cruz Island. These sites were formerly used or designated for U.S. chemical munitions dumping. An additional area southeast of Santa Barbara Island is charted as being a disused explosives dumping area.

Ocean dumping near the project area may lead to transport of material to the project area. Impacts of ocean dumping are not well understood and are highly dependent on such factors as: ocean currents and distribution of contaminants, chemical interactions of dumped materials in water and associated degradation time, and short term and long term biological impacts (from absorption and smothering) on living marine resources such as invertebrates, marine mammals and fishes. Most marine debris is land-based in origin with sources such as: malfunctioning sewage treatment plants; sewer overflows and inadequate solid waste programs and facilities; and beach users. Marine debris also comes from illegal trash dumping at sea. Marine debris poses a threat to human health and safety; injures or kills marine mammals, seabirds and sea turtles through ingestion and entanglement, and, is unsightly from an aesthetic point of view.

Industrial Effluents

Industrial effluents may enter coastal waters near the project area directly from desalination plants and other operations. At Gaviota, Chevron U.S.A. Inc. (Chevron) Gaviota Oil/Gas operates a seawater desalination plant, a wastewater treatment plant for produced water from crude oil and natural gas production, and a waste water disposal system operating under an NPDES Self- Monitoring Program. The outfall separates the oil and gas from the produced water, which is treated by means of induced-gas flotation and settling and is discharged to the Pacific Ocean through a 5200 foot outfall and diffuser system. Chevron discharges combined desalination plant wastewater and treated oil and gas plant wastewater to the ocean through the Santa Barbara Channel. Due to the low intake velocity and because the intake entrance is five feet above the ocean floor, use of the intake structure will not adversely affect nearby marine life. The Environmental Protection Agency classifies this as a minor discharge.

Industrial effluents can include toxic organic chemicals (detergents, oil, industrial solvents) and toxic metals (mercury, lead). Industrial contaminates can affect marine organisms at several levels: metabolic impairment or damage at the cellular level; physiological or behavioral changes at the organism level; changes in mortality or biomass at the population level; and changes in species distribution or altered trophic interactions at the community level (in Klee 1999).

Municipal Treatment Plants

Ocean discharge of treated sewage is common throughout the region and country. Six sewage outfalls, with varying levels of sewage treatment, discharge into the Santa Barbara Channel (see chart below). Section 402(p) of the Clean Water Act (CWA) requires that storm outfalls (e.g. surface runoff) be considered point runoff.

The treatment plant at Oxnard, along with the Santa Clara and Ventura rivers, are the largest sources of nutrients and contaminants into the Santa Barbara Channel. Pursuant to CWA, municipalities are required to provide secondary treatment (physical and biological) treatment of discharges. However, Section 301 (h) of the CWA provides for a waiver of the full secondary sewage treatment requirement if certain conditions are met demonstrating equivalent treatment. The U.S. EPA issues such a waiver to the Goleta Sanitation District.

The discharge of sewage into coastal waters is the cause of major impacts on humans and coastal and marine resources including: the introduction of disease-causing bacteria; eutrophication or the introduction of excess nutrients causing excess algal growth and oxygen depletion; and the introduction of toxic wastes such as heavy metals and Polychlorinated Biphenyls (PCBs).

4.2.3.1 Importance of Habitat Loss, Degradation, and Modification

Coastal watersheds and wetlands influence the ecology of the nearshore ecosystems of the SCB. There are 24 major drainage systems within the 32,000 square km of the SCB. Of these, 53 percent of the drainage area is controlled by major water retention structures, such as dams and reservoirs. In general, coastal watersheds of southern California have been redirected to serve agricultural and industrial interests and urbanization.

The rivers and creeks of southern California have undergone extensive damming and channelization, resulting in minimal sediment but maximum pollutant delivery to the ocean. The rivers of southern California no longer flow naturally to the ocean. Hence, the rivers, creeks, and coastal watersheds of the region no longer support the extensive wetlands of the past. A total of twenty-eight estuaries and wetlands occurred along the south coast in 1850 prior to development. These wetlands were discontinuous in distribution, each associated with a separate river or creek system. The size and character of each was a product of its particular hydrologic regime, degree of protection, and location on the coast.

Wetlands are physically linked to a watershed by the delivery of water, sediment, and nutrients to the wetland from the watershed. Within a particular geologic context, water, sediment, and nutrients from the watershed define the type of coastal wetland that emerges.

Wetlands in southern California occur in various ecosystem contexts (e.g., lagoons, rivers, lakes, ponds), but have origins related to several major physical processes. Wetlands that develop as a result of fluvial processes occur in riparian corridors, such as along the Santa Clara River. Here, riverine and palustrine wetlands occur in proximity to estuarine and marine wetlands when a river reaches the coast and tidally-influenced water regimes bearing ocean-derived salts meet waters and habitats of continental origin (Ferren et al. 1996).

Ferren (1985) summarizes from various sources the events that marked important changes in land ownership and land use of southern California's wetlands and watersheds. Historically, coastal wetland and estuarine habitats were often seen as a dumping area or a breeding ground for disease-carrying mosquitoes. Federal, State, and local policies to drain, fill, or somehow convert wetlands to more "productive" agricultural and urban land uses were the norm, resulting in widespread direct destruction of wetland habitat. Significant ecological impacts to wetlands continue through site drainage, dredging, and filling; hydrologic modification including flood control and water supply projects; pollution from point and non-point sources; and introduction of invasive exotic species.

Notable examples of wetland types that largely have been eliminated in southern California include: (1) estuarine wetlands (i.e., salt marshes) as an entire subsystem at 75-90 percent (Zedler 1982), (2) "the riparian community" at 90-95 percent (Faber et al. 1989) including loss of 40 percent of the riparian wetlands in San Diego County during the last decade alone (CDPR 1988); and, (3) vernal pools at 90 percent (Zedler 1987). These losses have contributed directly to the reduction in coastal and marine biodiversity of southern California, as evidenced by estimates that 55 percent of the animals and 25 percent of the plants designated as threatened or endangered by the State depend on wetland habitats for their survival. California ranks second in the nation in the total number of listed threatened and endangered aquatic species.

Coastal Development

Coastal development has significantly changed the ecological relationships and processes of coastal processes and nearshore marine environments (Leet et al. 2001). When human activity fragments and severs the connection between coastal watersheds, wetlands and the marine system, the biological, physical and chemical processes of fragile wetlands and the nearshore marine ecosystems are changed. As these biophysical and chemical processes are changed by human activity, the general health and integrity of wetlands is degraded to the point where animals, such as shorebirds, plants, and fishes decline. While such changes have not occurred on the Channel Islands themselves, the changes to the neighboring coastline have affected the overall biological health of the region.

Introduction of Nuisance and Invasive Exotic Species

Intentional or accidental introduction of invasive species may often result in unexpected ecological, economic, and social impacts to the estuarine environment. Through predation and competition, introduced species have contributed to the eradication of some native populations and drastically reduced others, fundamentally altering the food web. Feral cats are now a major predator in many coastal wetland ecosystems. Other impacts include: 1) alteration of water tables; 2) modification of nutrient cycles or soil fertility; 3) increased erosion; 4) interference with navigation, agricultural irrigation, sport and commercial fishing, recreational boating, and beach use; and 5) possible introduction of pathogens. Sources of introduced species include ship ballast, mariculture and aquarium trade.

The invasion of exotic species is one of the most serious threats and human-related impacts to the integrity and health of coastal and nearshore marine ecosystems (Leet et al. 2001). Such animals and plants are also referred to as nonnative, introduced, or nonindigenous species. There is a range of nonnative species of marine, coastal and nonmarine origins in the SCB. There has been a rapid increase of nonnative tunicates, for example, in southern California harbors and marinas.

No comprehensive surveys have evaluated the scope and impact of nonnative species on the bays, harbors and marinas of southern California. Studies of nonnative organisms in the San Francisco Bay and Delta estuary have described no less than 234 nonnatives, with over 100 different species of aquatic invertebrates alone. Several of these species will likely arrive in southern California, including the introduced green crab (*Carcinus maenus*).

In San Diego Bay, current estimates of the number of exotic marine species includes one species of marine algae, one marine protozoan, 47 marine invertebrates, and five marine fish. There are also 28 species of nonnative coastal plants in the watershed as well.

The nonnative marine species are found in benthic, fouling, and water column habitats. Coastal plant nonnatives are found in sand dunes, mudflats, salt marshes, riparian zones, filled wetlands sites, upland transition zones, and restoration sites (Zedler 1982). Several nonnatives species (rats, house mice, European starlings, opossum, and cats) prey on birds and sensitive species. These species in particular have affected populations at the Channel Islands.

Sources of nonnative marine species include:

- Ballast water in international ships that is discharged while docking.
- Attachment to hulls of ships and pleasure boats;
- Attachment to an intended introduced species, such as oysters for commercial harvesting; Intended introduction for commercial and recreational fishing or mariculture;
- Release of unwanted organisms by aquarists or bait fishers; and
- Natural spread from original point of introduction.

Nonnative species can have several different types of impacts on native species, including:

- Replacement of a functionally similar native species through competition;
- Inhibition of normal growth or increased mortality of the host and associated species;
- Serious species competition caused by extremely high population densities from lack of natural predation;
- Development of novel predators or novel prey;
- Creation or alteration of original substrate and habitat;
- Hybridization with native species; and
- Direct or indirect toxicity (e.g., toxic diatoms).

In addition to ecological damage, exotic species can cause significant economic impacts to boats, commercial fisheries, and marine structures.

In summary, the continued health and biodiversity of coastal and nearshore ecosystems of the south coast depend on the maintenance of high-quality habitat. The same areas that often attract human development also provide essential food, cover, migratory corridors, breeding/nursery areas for a broad array of coastal and marine organisms.

4.2.4 Geology

The northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) parallel the east-west trend of the coast and vary from about 13 to 25 miles offshore. Santa Barbara Island lies about 40 miles south of Point Mugu, California. These islands are all located within the geologic region known as the Continental Borderland (Norris and Webb 1990). The Continental Borderland is the section of offshore California between Point Conception and Punta Banda in Baja California (Mexico). Continued large-scale overriding of the North American Plate by the Pacific Plate in southern California caused movement along the San Andreas Fault System (Dailey et al. 1993). The Continental Borderland, with its wide shelf and series of laterally shifted blocks, resulted from this movement. It extends seaward for up to 300 miles (Dailey et al. 1993). Unlike most wide continental shelves that consist of gently sloping platforms interrupted by low banks and occasional canyons, the Continental Borderland is a region of basins and elevated ridges. The Channel Islands are the portions of the ridges that rise above sea level, as shown in a map of the bathymetry of the region (Figure 4-1). The highest point in the Channel Islands is Picacho Diablo on Santa Cruz Island, with an elevation of 2,450 feet (747 meters).

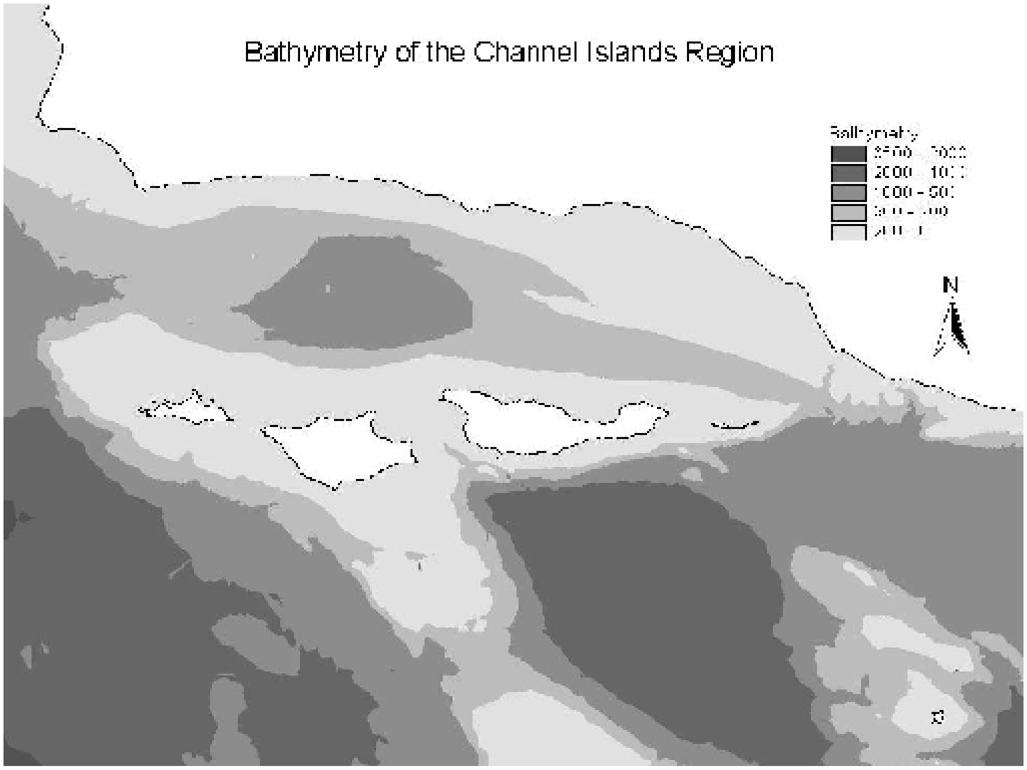

Figure 4-1. Bathymetry of the project area.

Basin-and-trough slopes account for 63 percent of the Borderlands area, basin-and-trough floors represent 17 percent of the area, and the islands comprise 1.1 percent of the area (Norris and Webb 1990). The Santa Barbara Basin, oriented east-west in parallel with the coastline and the islands, lies between the islands and the mainland, and is approximately 1,650 feet (500 meters) deep (Figure 4-1). The remaining basins trend northwest. The basins nearest the mainland have the shallowest depths, flattest floors, and thickest sediment fill. The northwest-trending basins range in depth from 1,650 to 8,250 feet (500 to 2,500 meters). The seaward edge of the Continental Borderland is the Patton Escarpment, a true continental slope that descends 13,200 feet (4,000 meters) to the deep ocean floor (Norris and Webb 1990).

There are at least 32 submarine canyons in the Continental Borderland. Along the mainland coast are six prominent canyons that are thought to be related to the modern shoreline. Other coastal canyons appear to be related to the shoreline and lower sea levels during the Ice Age that ended approximately 12,000 years ago (Norris and Webb 1990). There are also canyons that are cut into offshore basins in the region (Dailey et al. 1993).

Tectonically, the four northern Channel Islands form an east-west mountain chain along the southwest border of the Transverse Range physiographic province (Weigand et al. 1994). The island chain appears as a highly faulted, east-west trending anticlinorium (Weaver et al. 1969). The Transverse Ranges are unusual because their topography, and the faults and folds that produce it, is oriented east-west. There are about 30 principal, east-west trending faults in the Channel Islands area (Norris and Webb 1990). Santa Cruz Island and Santa Rosa Island are both bisected by east-west trending faults that continue offshore. These two faults interconnect with the southern frontal faults of the western Transverse Ranges farther east, such as the Dume, Malibu Coast, and Santa Monica faults, and form a part of a 200-kilometer-long system that extends from Pasadena to San Miguel Island. The Channel Islands Fault Zone, a major fault system, lies beneath the Santa Barbara Channel north of Santa Cruz Island (Sorlien 1994).

The Channel Islands area is believed to be the offshore extension of the Santa Monica Mountains, which extend from north of Los Angeles westward to San Miguel Island (Norris and Webb 1990). The oldest rocks in the region are metamorphic rocks of the Jurassic period (208 to 144 million years ago). Marine and non-marine terrace deposits of Pleistocene age (1.8 million to 10,000 years) and younger overlie the Miocene rocks on the Channel Islands (Norris and Webb 1990). San Miguel and Santa Cruz Islands have locally thick marine terrace deposits.

Sediments deposited in the Borderlands region include sand, silt, clay, and biogenic particulate (aggregates of planktonic origin (Dailey et al. 1993). Sand, silt, and clay are discharged by rivers during the winter rainy season. Waves carry the sediment in suspension along the shore within the beach and inshore zone. Periodic strong storms produce long period swells and turbulence, and move the sand offshore to the inner and central shelf. Nearshore submarine canyons intercept much of the transported sand. Lack of turbulence at depth prevents these sediments from being re-suspended. Silt and clay suspended in the water slowly settle out as the water circulates through a general pattern. The pattern of surface water circulation in the Channel Islands tends to move fine suspended sediment into the Santa Barbara Basin from the California Current System to the west and through the Anacapa Passage to the southeast. As a result, the rate of silt and clay deposition in the Santa Barbara Basin is high (Dailey et al. 1993). Biogenic particulate represent 20 percent of the borderland sediments (Dailey et al. 1993). Unlike the sediments discharged seasonally by rivers, the biogenic particulate are produced continually. Seasonal blooms of algae increase the rate of biogenic particulate production. Borderland sediments also include carbonate, opaline silica, and other organically derived matter (Dailey et al. 1993). A thick blanket of this sediment covers most of the borderland (Norris and Webb 1990). Sediments in the project area have been classified according to their dominance by sandy or rocky sediments (Figure 4-2).

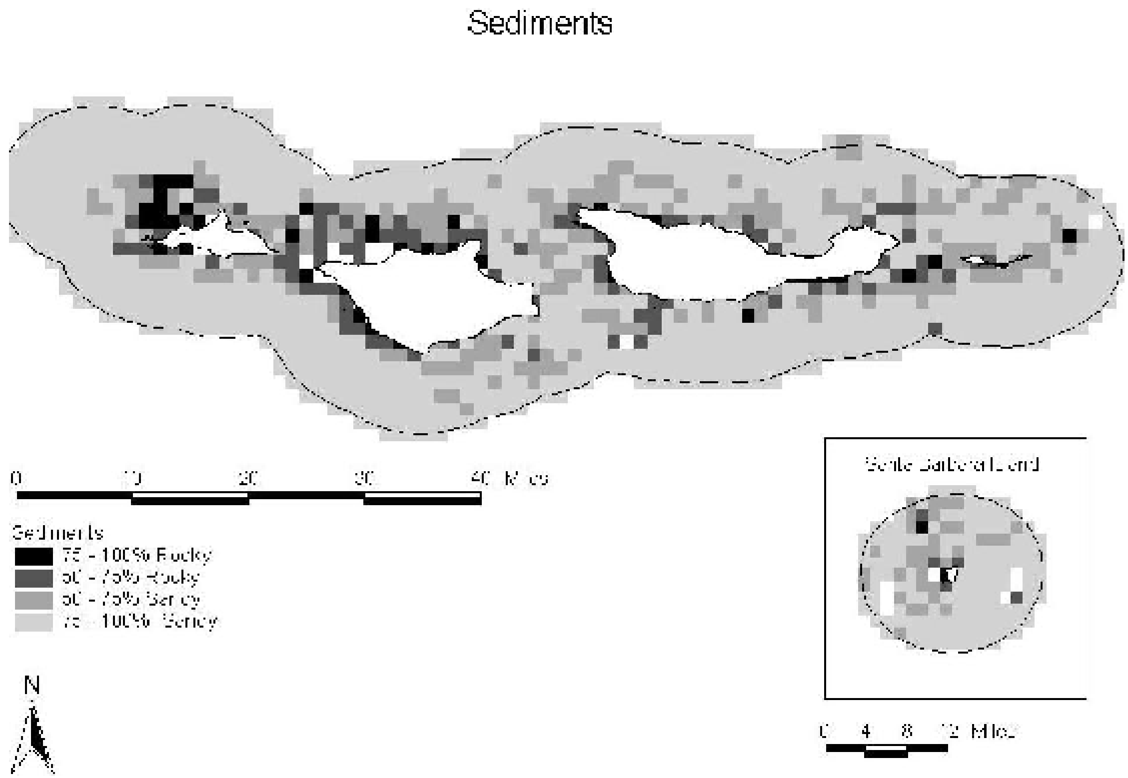

Figure 4-2. Bottom sediment types in the project area.

4.2.5 Oceanography

The equatorward flowing California Current and the poleward flowing Southern California Countercurrent dominate the mean water circulation in the Southern California Bight (Dailey et al. 1993). In the project area, currents in Santa Barbara Channel include patterns of warm, saline water from the Southern California Countercurrent and the colder water from the California Current. Upwelling often occurs where these water masses meet, near the massive headlands of Point Arguello and Point Conception, as well as along much of the California coast, depending on the season. Oceanographic thermal fronts are abundant in the Santa Barbara Channel and form as a consequence of upwelling and of current shear between the two primary currents (Harms and Winant 1998). Near Point Conception, the continental shelf is broad and deflects the south-flowing California Current offshore of the SCB and along the shores of the northern Channel Islands (Brink and Muench 1986; Browne 1994).

Offshore circulation in the region is a dynamic system that results from the interaction of large-scale ocean currents, local geography, and the unique basin and ridge topography of the ocean bottom in the SCB. The California Current is the major ocean current moving through the offshore region.

Year round, this current brings cold, fresh water from the Gulf of Alaska southward down the coast of California. At Point Conception, where the coastline turns east, the California Current moves farther offshore as it continues its southward flow. Near the U.S.- Mexican border part of the California Current turns east and then north, and flows back up along the coast and into the Santa Barbara Channel. This directional shift creates a large eddy known as the Southern California Countercurrent or the Southern California Eddy (Hickey 2000a). The Southern California Countercurrent moves warm water from southern California north westward up the coast (Hickey 2000b) At the eastern end of the Channel Islands, the Southern California Countercurrent separates into two parts. One part flows north through the Santa Barbara Channel. The other part flows westward south of the Channel Islands (Hickey basin exchange). The California Current and Southern California Countercurrent are both strongest in the summer (Hickey 1993). During the spring, the countercurrent disappears, and surface flow throughout the SCB tends to be southward (Hickey 1993).

Upwelling currents also influence circulation in the Channel Islands. These currents are the result of prevailing winds and the orientation of the coastline. Due to a process called Ekman transport, wind blowing over water in the northern hemisphere moves the surface water about 45 degrees to the right of the wind direction. Where the wind pushes surface water away from a coastline, deeper water moves up toward the surface, creating an upwelling current. Along the north-south oriented coast of California, winds blowing from the north move surface water westward, away from the coastline, and create upwelling currents that bring colder water to the surface (San Francisco State University 2000). At Point Conception, where the coastline makes an almost right-angle bend to the east, upwelling essentially ceases. Upwelling is rare along the mainland coast of the Santa Barbara Channel because the headlands at Point Conception shelter the east-west oriented channel from the strong northwesterly winds that generate upwelling (Love et al. 1999). Point Conception is the last major upwelling center on the west coast of the United States, and marks a transition zone between cool surface waters to the north and warm waters to the south (Love et al. 1999). However, upwelled water from regions north of the SCB appears to enter the western end of the Santa Barbara Channel and move eastward along its southern boundary (Hickey 2000a).

Within the Santa Barbara Channel, a localized cyclonic gyre circulation pattern exists year-round (Hendershott and Winant 1996; Lagerloef and Bernstein 1988) with seasonal variations in intensity. In general, cool water enters the channel from the west and flows eastward along the Channel Islands while warm water enters the channel from the east and flows westward along the coast.

Nishimoto and Washburn (in prep.) found that the eddy circulation in the Santa Barbara Channel extended to depths of at least 650 feet (200 meters), or nearly half the total channel depth, and suggest that persistent cyclonic eddies play an important role in maintaining marine populations through climate changes. Cold water uplifted in the center of the eddy may provide an additional source of nutrients during a shift to a warm-water regime, increasing primary productivity and the amount of food available for fish. Nishimoto and Washburn (in prep.) found large aggregations of juvenile fishes concentrated in an eddy in the Santa Barbara Channel. The researchers suggest that high food availability and feeding success contributed to faster growth and higher survivorship of these fishes. Nishimoto and Washburn (in prep.) also noted that the fishes were entrained in the eddy current in their larval stages and remained there until they passed the juvenile stage, when they grew strong enough to escape the circulating current.

Hickey (2000a) found that the sediments in ocean basins of the SCB are near anoxic to anoxic, and that the anoxic area is increasing. Expansion of the anoxic areas reduces the ability of the basin sediments to support marine life. The high ridges between the basins essentially prevent influx of oxygen-bearing water into the basins, which is important for maintaining oxygen levels within the basins. The events that bring oxygen to the basins are associated with processes in the upper water column above the basin. Strong upwelling and southeastward flow from the Santa Barbara Channel into the Santa Monica Basin appear to drive cold, denser water over the ridges into the basins, where it mixes with the ambient water confined within the basins. Influxes of oxygen-bearing cold water to the basins occur only for a few days at a time, after intervals of several years (Hickey 2000a). The Santa Barbara Basin, which lies between the Channel Islands and the mainland, is relatively shallow (1,640 feet/500 meters). An intense coastal upwelling event off Point Conception caused rapid renewal of the water in this basin. Within the last 40 years, water in the Santa Barbara Channel has overturned several times (Hickey 1993).

Waves in the Santa Barbara Channel are produced by seasonal swells crossing the open ocean, the sheltering effect of Point Conception and the Channel Islands, the variable wind fields that arise from the mountainous coastal and island topography, and the complex shallow water bathymetry within the channel (O'Reilly et al. 2000). Deep water swells from winter storms typically enter the channel from the west or west-southwest, for the most part unbroken by the Channel Islands. In the summer, deep water swells originate in the south Pacific, and encounter the Channel Islands as they move north toward California. The islands shelter most of the channel and the south-facing coast from summer swells, significantly limiting wave heights. South swells from storms near New Zealand enter the western end of the channel while those originating farther east near South America are almost entirely obstructed. South swells travel past Anacapa Island and reach the coast near Ventura and Rincon Point. Rare swells originating from the southeast can reach the coast at Santa Barbara (O'Reilly et al. 2000).

Much of the uniqueness of the SCB is due to the mixing of water masses from the southerly flowing cold California Current and the northerly flowing warm Southern California Countercurrent. These complex water movements result in differential temperature, nutrient, and larval recruitment conditions among the islands and along the coast north and south of Point Conception. In addition, prevailing winds periodically push surface water offshore from the Point Conception area, causing upwelling of cold, nutrient-rich water that bathes the northwestern islands, but rarely reaches the southeastern islands. It is difficult to separate the effects of temperature, nutrients, and larval drift on the distribution and abundance of marine life. Because the oceanographic influences typically covary, temperature is the easiest parameter to measure, and temperature clearly has major effects on marine life; it has become the standard means for characterizing northern (Oregonian) versus southern (Californian) biotic assemblages.

Broad-scale sea surface temperatures (SST) obtained from satellite infrared photographs (with ground truth from oceanographic data buoys) provide the best long-term records of concurrent temperature regimes throughout the Channel Islands. Depending on the depth, season, and particular location, surface temperatures may differ considerably from subsurface values, yet SST do reflect reasonably consistent general temperature relationships (List and Koh 1976; Bernstein et al. 1977). Water temperature regimes for nearshore habitats are not completely known. Specific data are available for particular locations, depths, and times. Deepwater temperature data are primarily available from periodic California Cooperative Oceanic Fisheries Investigation (CalCOFI) cruises.

Mean monthly SST for each of the Channel Islands as well as at Point Conception and Los Coronados Islands (near San Diego) for the 18-year period from 1982 to 1999 reveal characteristic trends that confirm the transitional nature of this special biogeographic region. All locations show a generally similar pattern of seasonal fluctuations, with lowest SST from January to March (except for Santa Rosa and San Miguel Islands and Point Conception, where upwelled water flowing southeast from Point Conception causes low SST also in April and May) and highest SST from July to October. Except for the pairs Santa Catalina/San Clemente and San Nicolas/Anacapa, the locations have consistently separate temperature regimes. North/south SST differences are greatest in August (5.0 degrees Centigrade [C]) and least in January (1.6 degrees C). Overall, there is a clear southeast to northwest trend of decreasing surface water temperatures for the 10 representative locations that correlates well with differences in species assemblages (Engle 1994; Murray et al. 1980; Murray and Bray 1993; Seapy and Littler 1980; Thompson et al. 1993). The warmest areas are Los Coronados (San Diego), Santa Catalina, San Clemente, and Santa Barbara Islands. San Nicolas, Anacapa, and Santa Cruz Islands are intermediate. The coldest regions are Santa Rosa, San Miguel, and Point Conception.

Temperature-related oceanographic phenomena influencing marine life at the islands vary considerably over time scales ranging from minutes to decades or more. Many organisms are adapted to withstand typical short-term fluctuations; however, seasonal or longer trends may kill sensitive species or enhance survival of tolerant species, resulting in profound community effects (see Tegner and Dayton 1987; Dayton et al. 1992). For long-term perspective, daily surface water temperature records taken at the Scripps Institution of Oceanography pier (La Jolla) since 1920 (the longest consistent data available) reveal remarkable long-term trends that likely occurred in similar fashion in the Channel Islands.

Notably, the 32-year period from 1944 to 1975 was characterized by cooler than average temperatures, except for the 1957 to 1959 El Niño years. In contrast, the 23-year period from 1976 to 1998 has been warmer than the 78-year mean, with a few minor exceptions. This recent multi-decade, warm-water trend helps explain key community changes documented at the Channel Islands during the 1980s and 1990s, including increased numbers of southern species at the northwestern islands, "disease" epidemics, other die-offs, and sea urchin overgrazing phenomena. In addition to oceanographic and climate-related factors, overfishing has been identified by marine scientists as the primary cause for the significant decline in the abundance and distribution of marine life associated with kelp ecosystems within the Channel Islands area (Jackson et al. 2001).

4.2.5.1 Importance of El Niño Events

Environmental fluctuation is an important factor influencing the distribution and abundance of marine life of the northern Channel Islands. In the SCB, El Niño (EN) and La Nina contribute to environmental fluctuation. El Niño is characterized by a large scale weakening of the trade winds and warming of the surface layers in the eastern and central equatorial Pacific Ocean. El Niño events occur irregularly at intervals of 2-7 years, although the average is about once every 3-4 years. They typically last 12-18 months, and are accompanied by swings in the Southern Oscillation (SO), an interannual see-saw in tropical sea level pressure between the eastern and western hemispheres. During El Niño, unusually high atmospheric sea level pressures develop in the western tropical Pacific and Indian Ocean regions, and unusually low sea level pressures develop in the southeastern tropical Pacific. SO tendencies for unusually low pressures west of the date line and high pressures east of the date line have also been linked to periods of anomalously cold equatorial Pacific sea surface temperatures (SSTs) sometimes referred to as La Niña.

Strong El Niños, that begin off South America, can eventually influence the climate, resources, and biodiversity of California's marine and coastal environment (Norton et al. 1985). A "California El Niño" is characterized by warm sea surface temperatures, a deeper surface mixed layer, a depressed thermocline, nutrient-poor water, greater poleward flow, and an anomalous high sea level (Barber and Chavez 1983; Dayton and Tegner 1984; Tegner and Dayton 1987; North et al. 1993). El Niños impact forests of giant kelp in California in a variety of ways that result in little or no canopy being produced, depending upon the severity of the event. Such impacts also affect kelp forest population dynamics, succession, and competitive interactions among kelp forest kelp species (Tegner et.al. 1997).

The impact of the El Niño in California depends on the strength of the event. Mild El Niños, that slowed kelp growth, were felt along the coast of California during 1977-1978 and 1992-1993. Especially strong events impacted kelp resources and stopped commercial kelp harvesting off California in 1941, 1957-1959, and 1982-1984. The 1982-1984 El Niño was the largest ever recorded off South America and California (Rasmusson 1984).

Storms associated with the 1982-1984 El Niño also devastated kelp beds throughout California. The effects of this El Niño on giant kelp in southern California were studied by Gerard (1984), Dayton and Tegner (1984), Zimmerman and Robertson (1985), Dean and Jacobsen (1986), Tegner and Dayton (1987, 1991), and North et al. (1993).

Zimmerman and Robertson (1985) studied giant kelp forest at Santa Catalina Island during the 1982-1984 major event. They found that deepened isotherms associated with the El Niño resulted in severe nutrient limitation and very low kelp productivity. Frond growth rates were so low that terminal blades formed before the frond reached the surface, eliminating canopy formation. Frond initiation rates were extremely low and resulted in significant reductions in mean plant size. Plants growing above 33 ft were more severely affected by the nutrient limitation than plants growing at 66 ft. These results suggested that nutrient pulses associated with internal waves were critical for survival of giant kelp in nutritionally marginal habitats in southern California (Zimmerman and Robertson 1985).

The mean nitrogen content of giant kelp tissues (measured as percent dry weight), which typically ranges from 1 to 4 percent in southern California, can be used as an indicator of the nutritional status (Gerard 1982a; North et al. 1982). Gerard (1982b) concluded that the critical level representing no nitrogen reserves for growth was a nitrogen content of 1.1 percent for laminar tissue. Tegner and Dayton (1987) found some spring upwelling at Point Loma during the spring of 1983. Giant kelp at Point Loma had nitrogen reserves after the spring upwelling; basal blades averaged 2.7 percent N and canopy blades averaged about 1.5 percent N in early July, 1983. By October 1983, basal blades had dropped to between 1.1 to 2 percent N and canopy blades to between 0.8 to 1.0 percent N (Tegner and Dayton 1987).

The relative growth rates of juvenile giant kelp in southern California were substantially reduced during the 1982–1984 El Niño (Dean and Jacobson 1986). The lower growth rates were correlated with increased temperature and decreased nitrogen availability. Fertilization of juvenile plants with slow-release nitrogen-phosphorus fertilizer increased the growth rate of juveniles to levels previously observed when the temperature was low and nutrient levels were high (Dean and Jacobson 1986). The limitation in growth of juvenile giant kelp by levels of available nutrients during the El Niño was in contrast to the usual limitation in growth by irradiance during non-El Niño years. There was a shift in the relative importance of factors controlling growth of juvenile *M. pyrifera* during the El Niño (Dean and Jacobson 1986).

Large-scale, low frequency oceanographic phenomena, such as El Niño or La Niña play a very important role in kelp forest successional processes, population dynamics, and competitive interactions with understory kelps (Tegner et. al. 1997). El Niños can drastically reduce the standing crop and canopies of giant kelp in California, resulting in a cessation or reduction of kelp harvesting for many months. Aquaculture, algin, and herring roe-on-kelp industries can all be severely impacted by significant El Niños in California.

Environmental variations are important contributors to the unexplained distribution of many kinds of fish and shellfish. Consequently, the fishing of and reproductive success of some species are affected by environmental conditions, one of which is water temperature (Radovich 1961). Notwithstanding the impacts of environmental fluctuation in the SCB, Jackson et al. (2001) note that overfishing is the primary cause for the significant decline in biomass associated with kelp ecosystems.

The effects of water temperature on California's marine flora and fauna can be both beneficial and detrimental. Ocean temperature directly affects the metabolism and survival of adult fish, and the abundance and type of food available. El Niño Southern Oscillation events have had dramatic effects on the flow patterns of the SCB (Chelton et al. 1982). Changes in the flow patterns as well as the resultant changes in rain and weather patterns have been shown to have a number of biological impacts:

- population shifts in commercially harvested species, such as squid, rockfish and lobster;
- transport of enormous volumes of sediments and suspended materials from the mainland to coastal and offshore waters;
- disturbance to critical marine habitats, notably storm and water temperature damage to kelp forests.

El Niño events cause proportional reductions in the growth and reproductive success of organisms within coastal ecosystems. Warm waters and the intrusion of a different water mass associated with El Niño events may change the abundance, species composition, and temporal dynamics of the prey community in local species assemblages. Depending on the nature of an organism's diet and patterns of energy storage and mobilization for reproduction, adult condition and spawning efforts may be adversely affected. Starvation and thermal stress may have direct physiological effects on fecundity, timing of spawning, and egg viability in both fishes and invertebrates, especially if they are sedentary or limited-range species (Barber and Chavez 1983; Bailey and Incze 1985).

It is important to note that marine life of the project area adapts within this ecosystem and have developed strategies which allow them to recover under natural conditions (Tegner and Dayton 1987). Some stocks, such as herring, are adapted to living in an environmentally variable coastal zone (Bailey and Incze 1985). Birds and pinnipeds are known to abandon their young so that the adults may use available food for their own survival (Barber and Chavez 1983).

However, the ability of a particular species to recover may be reduced if the El Niño event is particularly severe or prolonged. Early life history stages of organisms are especially vulnerable to the effects of warm waters, altered food production, and changes in transport regimes (Bailey and Incze 1985).

Overexploitation of a particular species may further hamper or prevent recovery (Cushing 1982). Overfishing may cause recruitment failure by either reducing the abundance of certain key species within an ecosystem, or by reducing the adult population size. Consecutive years of poor recruitment increases the likelihood of a total population collapse (CINMS 2001).

Highly migratory or mobile species may be able to avoid the warm El Niño conditions by either migrating further north or into deeper waters. However, bioenergetic costs associated with migration may pre-empt somatic growth and/or gonadal development. Fecundity, timing of spawning, and egg viability may be adversely affected by the weakened condition of adults (Bailey and Incze 1985).

Migration to cooler waters may present opportunities to expand a species' range by colonizing new areas. Successful colonization will depend upon the species' ability to cope with local dynamics like the timing of plankton blooms and current patterns, new interspecific interactions, such as competition and predator-prey relationships, and local conditions once the El Niño conditions subside (Bailey and Incze 1985).

Species more commonly found in tropical waters may migrate to, or be advected into, temperate waters during El Niño events (Squire 1983). For example, red crabs (*Pleuroncodes planipes*), pelagic tunicates, and fishes such as albacore, barracuda, dorado, yellowfin tuna, marlin, and triggerfish have been noted to occur far to the north of their usual range. In general, highly migratory species like yellowtail and some pelagic species such as barracuda and sardines thrive during warm water events. In the case of barracuda and yellowtail, these fish move north into Californian waters in response to the movement of warm water from the south. Sardines spawn in water greater than 55.4 degrees Fahrenheit (13° C). Higher water temperatures probably enhance the reproductive success of sardines. The arrival of new species may introduce new interspecific reactions that may alter the local community structure (Bailey and Incze 1985).

The displacement of species during El Niño events is reflected in depressed commercial catches of temperate-water species such as salmon, northern anchovy, lingcod, sablefish, rockfishes, dungeness crab, market squid, and shrimp (Smith 1985). During El Niño events, cold water species such as anchovy and salmon suffer declines. For anchovies, a warm water event merely signals the lack of preferred food such as plankton. Salmon, however, cannot metabolically withstand substantial increases in water temperature. Thus they will move away from areas of warm water. For those species at or near the bottom of the food chain, such as algae and lower invertebrates, the cessation of upwelling can be fatal. The dependence of these species on the nutrients found in cool upwelled water is well documented (Barber et al. 1985; Smith 1985). When the nutrients are depleted, the resulting mortalities and their effects can be felt all along the food chain (Barber et al. 1985).

Strong El Niño events are highly correlated with severe storms (Tegner and Dayton 1987). The community structure of kelp forests and other benthic habitats may be significantly altered following storm-induced disturbances. Recovery of plants damaged by storms may be hindered by the warm, nutrient-poor water associated with El Niño events.

For detailed discussions of some of the biological effects of El Niño events, refer to Bailey and Incze (1985) and Tegner and Dayton (1987).

4.2.5.2 Marine Ecosystem Disturbance

California Cooperative Fisheries Investigations researchers and other marine scientists have shown that large-scale changes, or what is referred to as a regime shift, in the physical and biological processes of the SCB and the Eastern Pacific can lead to change in the distribution and abundance of marine species within the SCB. Each regime shift changes the basic nature of marine ecology for several decades at a time (or on the order of several human generations). McGowan et al. (1998) state that the last regime shift occurred in 1977.

Based on an analysis of CalCOFI data, Roemmich and McGowan (1995a,b) document large-scale changes in primary and secondary productivity throughout the SCB between 1951 and 1993. Hayward et al. (1996) and McGowan et al. (1998) show that large-scale biological responses in the marine environment due to climatic variations in the atmosphere has resulted in changes in geographical ranges and spatial patterns of species and in community structure. This evidence suggests that the maintenance of community structure and patterns of native species diversity has changed in accordance to hydrographic perturbations and climate-ocean variability.

A summary of the changes described by marine scientists is presented below:

The Euphotic Zone (upper sunlight zone of the sea, less than 120 m thick): Smith and Kaufmann (1994) show a long-term deficit in the supply of food necessary to meet the metabolic demands of the sediment community. The long-term increase in sea surface and upper water column temperatures and physical stratification in the system has resulted in a lower rate of supply of nutrients to the euphotic zone. This has lead to a decrease in productivity and a general decline of zooplankton and other species (e.g., larval fish production, seabirds, kelp production and a shift in benthic, intertidal community structure). Despite this decline in food supply, the food demand of the deep-benthic sea community remained constant. With the demand on food constant, and the supply diminishing, a net deficit in available food occurs.

Macrozooplankton: Since the late 1970s, macrozooplankton volume in the California Current has declined over 70 percent, in concert with increasing sea surface temperatures (Roemmich and McGowan 1995a,b; McGowan et al. 1998). Reduced macrozooplankton has a major impact at higher trophic levels by changing the nature of the food supply.

Fishes and Invertebrates: Department data show decreases in landings for several categories of groundfish, California sea urchin, swordfish and selected shark species, Pacific mackerel, Pacific herring, California halibut, market squid (for the period 1997-1998) among others. Dugan and Davis (1993) document the general decline in long-term productivity in 19 species of nearshore fishes and invertebrates in California from 1947 to 1986. A study by Love et al. (1998) of long-term trends in the SCB commercial fishing vessel rockfish fishery shows a substantial decline from 1980 to 1996, with extremely low catches from 1993 to 1996. In addition, the estimated abundance in streams south of Point Conception for steelhead rainbow trout (*Oncorhynchus mykiss*) probably on the order of a 100 - 300 adults (PFMC 1996).

Oceanic Birds: Ecological theory predicts that in a stable ecosystem those species occupying high trophic levels maintain native species diversity and community structure (Paine 1966). Upper trophic level animals such as pelagic birds are indicators of the health of the marine environment (Veit et al. 1996). Evidence suggests that the abundance of oceanic birds in the region and the SCB have declined steadily since 1988 (Veit et al. 1996, 1997). For example, the sooty shearwater, the most abundant bird in the SCB, has declined by 90 percent. Veit et al. (1996) show that the decline in bird biomass reflects considerable biological change within the California Current System. Veit et al. (1996, 1997) indicate that ocean warming and climatic events change pelagic bird abundance within the California current system.

Southern California Kelp: Starting in the late 1970s, Tegner et al. (1996, 1997), Tegner and Dayton (1991), and Dayton et al. (1992) show that kelp forests have suffered great damage. Tegner et al. (1997) show a two-thirds reduction in standing biomass since 1957 in southern California kelp forests.

Global Climate Change: There is also some indication that the frequency of these climatic events may be increasing (McGowan et al. 1998).

In summary, changes in atmospheric and oceanographic conditions have been shown to decrease or increase marine species abundance and distribution in the CINMS and the SCB.

4.3 Biological Environment

4.3.1 Biogeographic Provinces

The complex geography of the California Channel Islands influences ocean circulation (Browne 1994) and, consequently, the distributions of habitats and species (Dailey et al. 1993). Three main biogeographical regions emerge when the area is subdivided according to physical and biological differences using existing information (Valentine 1966; Horn and Allen 1978; Littler 1980; Ebling et al. 1980a,b; Kanter 1980; Murray et al. 1980; Seapy and Littler 1980; Apt et al. 1988; Engle 1993; Dugan et al. 1995 2000). Bathed by the California Current, San Miguel and northern Santa Rosa Island lie in the Oregonian bioregion, supporting biotic assemblages characteristic of central and northern California, Oregon, and Washington (Murray et al. 1980; Seapy and Littler 1980). Anacapa and the eastern tip of Santa Cruz Island are surrounded most of the year by temperate waters characteristic of the Californian bioregion (Murray et al. 1980; Seapy and Littler 1980). Sea surface temperature maps suggest that Santa Barbara Island and southern Santa Rosa and Santa Cruz Islands represent a transition between cooler and warmer temperate waters (ICESS 2001).

It is important to consider the dynamic nature of this transition between the two major biogeographical provinces. Persistent thermoclines may shift tens of miles, or more, during environmental fluctuations such as El Niño-Southern Oscillation (McGowan et al. 1998). For this document, however, explicit biogeographical boundaries were determined using available information on sea surface temperature (ICESS 2001) for rough guidance and, in the areas of sharpest transition, using boundaries that followed the deepest bathymetric contour (under the assumption that these might provide a significant boundary to movement of some species, especially nearshore species that rarely enter pelagic waters).

4.3.2 Habitat Types

Important habitats in the project area are classified according to a simple, multidimensional habitat classification, using depth, exposure, substrate type, and dominant plant assemblages (Table 4-1). The classification was conducted used existing maps and sediment samples taken throughout the project area. These included a Shoreline Inventory Database (MMS 2000) that describes a variety of coastal features in Santa Barbara County, a series of maps of over 5000 sediment grabs around the Channel Islands (Amuedo and Ivey 1967), a database of soft sediment samples in the northern Channel Islands (USGS unpublished data) and substrate maps of the sea floor around Channel Islands (MMS 1984).

These sources were combined using a Geographic Information System (GIS) to develop a comprehensive substrate map of the project area, divided into soft substrate (e.g., mud, sand, gravel) and hard substrate (e.g., rock, boulder, bedrock). A bathymetric map of the Channel Islands (Waltenberger 1995) was used to distinguish habitat types at the following depth intervals: shoreline, euphotic zone (intertidal-30 m), upper continental shelf (30-100 m), lower continental shelf (100-200 m), continental slope (>200 m). Dominant plant species, including giant kelp and seagrasses, form marine habitats used by diverse groups of invertebrates, fish, mammals and seabirds (Anderson et al. 1993). The potential distribution of giant kelp around the northern Channel Islands and Santa Barbara Island was determined from aerial photographs of the region between 1980 and 1989 (Ecoscan 1989). Most of the kelp (approximately 17.2 nmi2) occurred on the southwestern coasts of San Miguel and Santa Rosa Islands.

Table 4-1. Habitat classification and the approximate abundance of each criterion in each biogeographical regions in the project area.

Ecological Criteria	Units	Oregonian Bioregion	Transition Zone	Californian Bioregion
Coastline characteristics				
1. Sandy beach	mi of coastline	24.8	13.8	4.7
2. Rocky coast (low exposure)	mi of coastline	28.2	11.6	12.5
3. Rocky coast (high exposure)	mi of coastline	27.4	13.6	1.4
Substrate type and depth				
4. Soft sediment (0-30 m)	nmi^2	38.9	29.6	16.4
5. Hard sediment (0-30 m)	nmi^2	34.3	7.2	6.6
6. Soft sediment (30-100 m)	nmi^2	211.6	63.6	56.2
7. Hard sediment (30-100 m)	nmi^2	23.4	10.1	3.9
8. Soft sediment (100-200 m)	nmi^2	157	62.9	27.2
9. Hard sediment (100-200 m)	nmi^2	-	7.3	1.1
10. Soft sediment (>200 m)	nmi^2	226.7	176.9	160.7
11. Hard sediment (>200 m)	nmi^2	-	14.6	2.3
Additional features				
12. Emergent rocks (nearshore)	no. <1 nmi from shore	216	208	95
13. Emergent rocks (offshore)	no. >1 nmi from shore	12	5	1
14. Submerged rocky features (pinnacles, ridges, seamounts)	nmi^2	5.9	26.7	4
15. Submarine canyons	nmi^2	1	33.7	5
Dominant plant communities				
16. Giant kelp	nmi^2	16.1	5.9	1.8
17. Surfgrass	nmi^2	13.4	6.7	3.2
18. Eelgrass	nmi^2	0.3	0.1	0.2

4.3.2.1 Intertidal Habitat

The intertidal zone is comprised of a variety of coastal habitats that are periodically covered and uncovered by waves and tides. This transition zone between sea and land is the strip of shore ranging from the uppermost surfaces wetted during high tides to the lowermost areas exposed to air during low tides. The vertical extent of tidal change within the Channel Islands can be as high as 3 meters (+2.4 to -0.6 meters) during full or new moon periods. On surf-swept rocky cliffs, the wave splash can extend the marine influence upward another 5 meters or more. Shores with lesser slopes have broader intertidal surface areas although less splash influence. Low-sloping shores have intertidal regions tens of meters wide.

The intertidal zone is typically divided into four sub-zones defined by tidal exposure (Ricketts and Calvin 1968). The infrequently wetted splash zone includes the area from the highest reach of spray down to the mean high tide line. The high tide zone, exposed more often to air than water, extends from mean high tide level down to the average height of the higher of the two daily low tides. The middle intertidal zone, ranging from mean higher low water to mean lower low water (zero tide level), is typically covered and uncovered twice each day. The low intertidal is normally uncovered only by minus tides. In addition, tidepools, special intertidal features, allow pockets of continually submerged life to exist at varying shore levels. Intertidal habitats vary in the type of substrate and degree of exposure to surf. Bottom types include fine muds, sand, gravel, cobble, boulders, and bedrock. Rock types range from soft sedimentary to hard metamorphic forms. Rocks also vary in the extent of roughness, depressions, cracks, crevices, and vertical relief. Protected embayments and estuaries contain mostly fine particulate substrates while outer coast shores range in composition from sand to various rock types.

The plants and animals inhabiting intertidal shores are subject to periodic immersion in water followed by exposure to air. They must withstand varying degrees of wave shock, dramatic temperature changes, desiccation, and attacks from terrestrial predators. On unconsolidated muddy or sandy shores, algae are rare, and much of the invertebrate life, such as worms, crustaceans, snails, and clams dwell under the substrate. Rocky shores support a much richer assortment of plants and animals. Numerous green, brown, and red algae occur, as well as beds of surfgrass. A wide variety of sedentary invertebrates, including barnacles, limpets, and mussels compete for space with the plants in the intertidal zone. Mobile invertebrates, such as snails and crabs, often hide in crevices or under rocks, then emerge to graze on plants or prey on other animals. Fishes are limited to tidepools or passing through the intertidal zone at high tide. Seabirds forage in the intertidal at low tide. Some roost in aggregations on cliffs just above the shore. Seals and sea lions haul out on particular intertidal shores, sometimes in dense aggregations.

The Channel Islands experience varying degrees of exposure to winds, waves, currents, and water temperatures. Lacking major rivers and shallow coastal shelves, island shores are predominantly rocky. Of the five islands considered here, Santa Barbara has the most bedrock (74 percent), and Santa Rosa the least (62 percent). Santa Barbara Island also has the most boulder beaches (22 percent) while San Miguel Island has almost none (0.2 percent). San Miguel and Santa Rosa Islands have the most sandy beaches (36 percent and 33 percent). Sandy beaches on the Northern Channel Islands occur primarily on the southern shores, except for San Miguel Island, which has sandy beaches on north and south shores.

4.3.2.2 Subtidal Habitat

Subtidal habitats include those marine habitats ranging from the lower limit of the intertidal zone down to deepwater offshore. To separate nearshore from offshore environments, nearshore subtidal habitats have been defined as depths of 30 meters because these relatively shallow depths are most influenced by coastal oceanographic processes and light levels diminish rapidly in this zone such that few benthic algae exist at greater depths. Nearshore subtidal habitats include mud, sand, gravel, cobble, and bedrock substrates. Rock types range from soft sedimentary to hard metamorphic forms. Protected embayments and estuaries contain mostly fine particulate substrates, while outer coast shores range in composition from sand to various rock types. Though less variable than intertidal habitats, shallow-water shores are subject to dynamic physical processes, including wave exposures, along-shore currents, upwelling, temperature/salinity/nutrient differentials, and suspended sediment loads.

Typical shallow subtidal areas contain balanced assemblages of plants, invertebrates, and fishes, with giant kelp dominating. However, many shallow reefs overgrazed by sea urchins have little macroalgae and greatly reduced species diversity. Deeper current-swept reefs with less light for plants have well developed suspension-feeding invertebrate cover, including sponges, sea anemones, sea fans, plume worms, bryozoans, and tunicates. Some low-relief rock/cobble/sand habitats in high current areas are dominated by large numbers of filter-feeding brittle stars (*Ophiothrix spiculata*) or sea cucumbers (*Pachythyone rubra*).

Nearshore Subtidal - Soft Bottoms

Along unprotected shores, plants cannot anchor on the shifting sands, and surface-dwelling animals are limited to hardy species specially adapted to this rigorous, featureless environment. Such animals include sea pens, sea pansies, sand crabs, moon snails, sand dollars, sand stars, bottom-dwelling sharks and rays, and flatfishes. More animals and some plants occur on protected, stable sand habitats found in the lee of ocean swells or in deeper water less exposed to surge. In contrast to the relatively sparse community living above the sand, a diverse assemblage dwells within the soft sediment. These typically small infaunal organisms include worms, crustaceans, snails, and clams. Populations can be quite variable in shallow areas with heavy surge, but they become more stable in calmer and deeper waters.

Many sandy habitats at the islands have relatively steep slopes. The sand often is coarse shelly debris because there is little sediment runoff from land and strong water currents sweep organic material away. Stable sand habitats with fine grain sediments generally are limited to sheltered coves at canyon mouths, such as those found around Santa Cruz Island. A few of these locations have well-developed eelgrass meadows. Many other sandy habitats consist of patches of shelly sand between rock reefs, forming mosaics of hard and soft substrata. Spectacular rocky habitats at the islands are widespread, especially high-relief volcanic reefs with walls, ledges, caves, and pinnacles. Low-relief sedimentary reefs exist as well, particularly on Santa Rosa Island.

Nearshore Subtidal - Hard Bottoms

Rocky subtidal environments are capable of supporting thousands of plant, invertebrate, and fish species, depending on the extent of habitat heterogeneity and influence of physical factors such as water motion, light, temperature, nutrients, and sedimentation. Soft sedimentary reefs permit boring clams and sea urchins to create holes and depressions that also are utilized by other smaller creatures. These reefs can be broken up or worn down by waves and surge. In addition to hardness, rocks vary in the extent of roughness, cracks, crevices, and vertical relief, all of which provide microhabitats for a host of organisms, including worms, crustaceans, mollusks, brittle stars, and fishes. Water motion can increase ecosystem productivity by supplying planktonic food to filter and suspension feeding invertebrates such as sponges, cnidarians, plume worms, bivalves, and tunicates. In contrast, sedimentation can cover rock surfaces and reduce productivity by preventing settlement of spores and larvae, by clogging filtering apparatuses, and by blocking light required by plants.

Plants need light and nutrients for photosynthesis, hence are more abundant in shallow water. Numerous green, brown, and red algae occur, as well as surfgrass. Algae may form crusts, turfs, large blades, stalked plants, or tall kelps. Plants provide microhabitats and food for animals, but they also compete for space with sessile invertebrates. As light diminishes in deeper water, plants disappear. Here reefs become increasingly covered by attached invertebrates (e.g., sponges, sea anemones, cup corals, sea fans, plume worms, rock scallops, and tunicates), that in shallow habitats often were limited to vertical surfaces and under hangs not suitable for plants.

The distribution of shallow subtidal reefs is less well known than the distribution of the rocky intertidal reefs. Large-scale studies have not been done, and the rigorous ocean conditions in many areas make scuba diving surveys difficult. Often nearshore reefs are found where rocky intertidal habitat occurs. Kelp beds generally are good indicators of subtidal reefs (except for beds of the *Macrocystis angustifolia* form that occur on sand). Kelp canopies have been mapped by aerial surveys (Crandel 1915; Hodder and Mel 1978).

Short-lived, opportunistic species commonly occur on freshly exposed rock surfaces. Deeper nearshore habitats are often dominated by extensive algal cover, including red algae and palm kelps. The cold, nutrient-rich waters of the northern islands support well-developed assemblages of suspension-feeding invertebrates (e.g., sponges, anemones, plume worms, bryozoans, and tunicates), as well as algal grazers such as snails, sea urchins, and crabs. Fishes, such as rockfishes, represent the cold-water Oregonian Province.

<u>Offshore Subtidal</u>

Beyond nearshore subtidal depths are deep-water habitats extending from 30 to >200 meters deep and the continental slope. East of the continental slope, the Continental Borderland comprises ridges, basins, and submarine canyons. Prominent in the Santa Barbara Channel is the Santa Barbara Basin, which reaches a depth of 590 meters. Well over 90 percent of deep-water benthic habitats in the Channels Islands consist of fine sands in shallower portions, grading into silt and clay-dominated sediments in deeper portions (SAIC 1986; Thompson et al. 1993). These soft-bottom particulates are derived from terrestrial runoff and decaying plankton. Coarse sediments occur near Point Conception, and north of San Miguel Island (Blake and Lissner 1993). Fine sediments occur on the sill at the western end of the Santa Barbara Channel, and in the Santa Barbara Basin.

Records of the bottom composition for the remaining hard-bottom areas are incomplete and are based on old lead-line soundings, snags reported by fishermen, and geophysical surveys conducted by the U.S. Geological Survey (USGS) and oil companies. Direct observational evidence has revealed that many previously reported hard-bottom areas are not exposed rock; instead, the reefs are covered by soft sediments (SAIC 1986). Deep rock bottoms often are located offshore from major headlands and islands, and on the highest parts of undersea ridges, banks, and pinnacles. Most of the deep-water hard bottom substrates are low-relief reefs less than 1 meter in height; some reefs have 1- to 5-meter high features. Boulders and bedrock outcrops are the predominant rocky substrates. Higher relief pinnacles and ridges occur in some areas, such as off the northwest end of San Miguel Island.

Light disappears rapidly below 50-meter depths, thus offshore benthic habitats do not support marine plants. The fauna of these habitats have been described from remote grab, dredge, trawl, remote-operated vehicle (ROV), and manned submersible surveys conducted from surface vessels for research, fisheries, and environmental studies, especially those related to municipal outfalls and oil development activities. Major

deep-water biological surveys include those conducted for the Bureau of Land Management (BLM) (Fauchald and Jones 1979a,b), the Southern California Coastal Water Research Project (SCCWRP) (e.g., Allen et al. 1998), and the Minerals Management Service (MMS) (Blake and Lissner 1993; SAIC 1986).
Offshore deep-water communities have few species in common with nearshore communities, due especially to the cold temperatures and lack of light. The composition of deep assemblages depends particularly on sediment composition, water depth, vertical relief, and extent of siltation (SAIC 1986; Thompson et al. 1993). For a given depth, deep assemblages tend to be more similar over broad geographic ranges than shallow-water communities because the physical environment (e.g., temperature, salinity, darkness) is fairly stable. Most deep muddy-bottom invertebrates are detritus feeders while rocky-substrate invertebrates are predominantly suspension-feeders. Low-relief deep reefs often are heavily silted, with greatly reduced species diversity. Increasing siltation smothers attached invertebrates, gradually changing the habitat to soft bottom. Scour from deep-water currents also influences the distribution of abrasion-sensitive marine life.

The stability of most deep-water soft-bottom habitats permits greater diversity of infaunal (life within the substrate) and epifauna (life on or just above the substrate) compared to shallow particulate substrates disturbed by waves and surge. Typical infaunal on deep fine-sediment habitats include sea pens (*Stylatula elongata* and *Ptilosarcus gurneyi*), polychaete worms (*Heteromastus sp*., *Prionospio lobulata*, and *Chloeia pinnata*), echiuran worms (*Urechis sp*.), amphipods (*Orchestoidea spp., Photis spp., Polycheria sp., Oligochinus sp.,* and *Caprella spp.*), brittle stars (*Amphiodia squamata* and *A. urtica*), and small snails and clams (Family Mollusca). Epifauna include shrimp (*Pandalus spp*.), octopus (*Octopus spp.*), sea cucumbers (*Parastichopus spp.*), seastars (Class Asteroidea), heart urchins (*Lovenia spp.*), and flatfishes (Families Bothidae and Pleuronectidae). Fauchald and Jones (1979a,b, 1983) and Thompson et al. (1993) divide the assemblages into four major benthic habitats: (1) mainland shelves (50 to 150 meters) often dominated by brittle stars; (2) offshore shelves, ridges, and banks (50 to 500 meters) with brittle stars, the clam *(Parvilucina tenuisculpta*), the polychaete (*Chloeia pinnata*), and the amphipod (*Photis spp*.); (3) basin slopes (150 to 600 meters) with the polychaete worms most common in the Santa Barbara Channel; and (4) basin floors (deeper than 600 meters) where assemblages are not stable over time because these areas often experience anoxic conditions.

Common invertebrates on deep hard substrates include sponges, anemones, cup corals, sea fans, bryozoans, feather stars, brittle stars, sea stars, and lamp shells. Demersal fishes can be common, especially various species of rockfishes. In the northern Santa Barbara Channel, three principal hard bottom assemblages were described for outer shelf-upper slope depths (105-213 meter) in MMS surveys (SAIC 1986): (1) a low-relief assemblage dominated by anemones, brittle stars, and lamp shells; (2) a medium relief assemblage characterized by the anemone *Corynactis californica* and deep-water coral *Lophelia californica*); and (3) a broadly distributed community composed of the anemone *Metridium senile*, cup corals, and the feather star *Florometra serratissima*.

4.3.2.3 Kelp Forest Habitat

Giant kelp forms extensive underwater beds on rocky substrates (except the *M. angustifolia* form on the south coast occurs on sand) at shallow subtidal depths (3 to 30 meters) throughout the project area (Figure 4-3). Giant kelp, a keystone species, completely transforms reefs into lush underwater forests. This highly productive plant provides food, attachment sites, and shelter for a myriad of invertebrates and fishes. The dense thicket of kelp in the water column and at the surface is particularly important as a nursery habitat for juvenile fishes (Carr 1989).

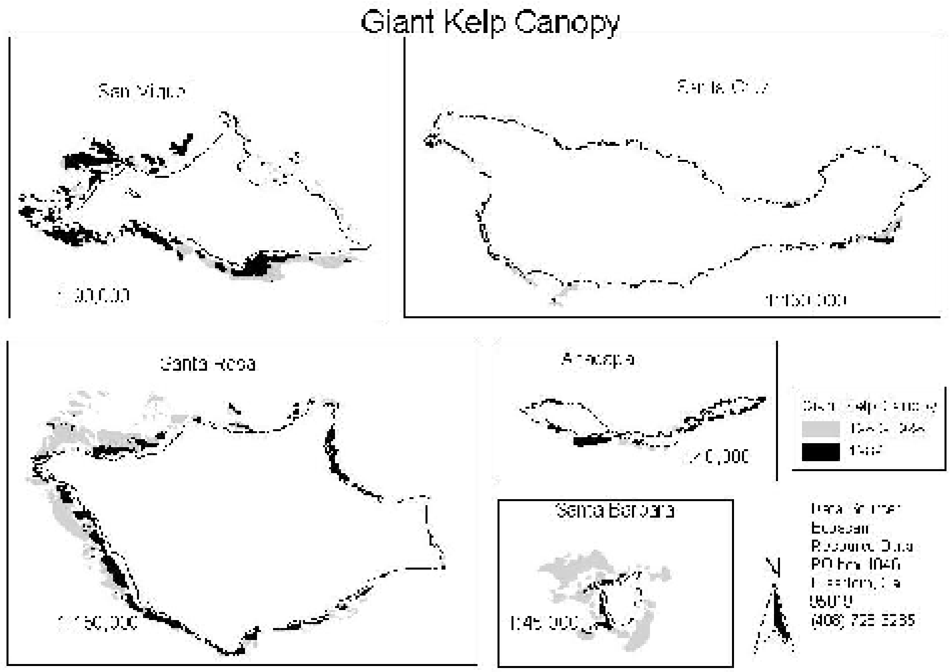

Figure 4-3. Giant kelp canopies of the project area.

These impressive underwater forests with extensive surface canopies are conspicuous and popular features of this region, important not only ecologically, but also recreationally and commercially. The complex vertical structure of highly productive kelp ecosystems provide food, attachment sites, and shelter for a diverse assemblage of plants and animals, many of which are targeted for sport and commercial harvest. Kelp itself is harvested commercially for use in a wide variety of food and industrial products. Giant kelp forests range from San Francisco south to central Baja California. Giant kelp is a perennial species that has multiple fronds buoyed up by pneumatocysts arising from a large holdfast. Individual fronds live only about 6 months (during which they may grow 30 meters or more in length), but new fronds are continually produced during the several year life span of the plant (Rosenthal et al. 1974). Giant kelp has a life cycle that alternates between the large sporophyte phase and a microscopic gametophyte generation.

The particular structure of plant and animal assemblages within kelp forests depends on many factors, including the nature and profile of the substrate, degree of wave exposure, water clarity, and temperature/nutrient conditions (Ebeling et al. 1980a; Foster and Schiel 1985; Hodder and Mel 1978; Murray and Bray 1993). Beds typically have several layers of understory algae that increase habitat heterogeneity (Dayton et al. 1984: Foster and Schiel 1985). Boa kelp, palm kelps, and bladder weeds can rise 1 or more meters off the bottom like bushes. Below these are smaller prostrate or low-growing algae less than 1 meter in height. Next lower can be a turf layer, and finally a crust layer often dominated by pink coralline algae. Kelp beds also are foraging habitats for seabirds and marine mammals. Cormorants dive through the forests seeking fish; while gulls, pelicans, and terns hunt surface fishes in or near the canopy. Where sea otters occur, they are closely associated with kelp beds, diving for a variety of invertebrates. Sea lions, seals, and occasional whales use kelp beds as foraging areas.

Kelp mortality can occur from various physical and biological conditions. Powerful storm swells can rip out plants that entangle other plants, resulting in considerable losses. These largely seasonal (winter) disturbances are most prevalent in exposed locations. High temperature/low nutrient conditions may cause deterioration of kelp in the warmest summer months and during El Niño periods (Foster and Schiel 1985; Murray and Bray 1993; Tegner and Dayton 1987). Increased turbidity and sedimentation in kelp habitats can reduce productivity and increase mortality, particularly of the microscopic gametophyte and tiny sporophyte stages (Dean and Deysher 1983). Grazing invertebrates and fishes consume kelp. Sea urchins are especially efficient at munching through kelp holdfasts, causing detached plants to drift away. Normally dwelling in crevices where they feed on drift kelp, urchins may emerge when drift plants are scarce and overgraze entire kelp beds, turning areas into "urchin barrens" (Ebeling et al. 1985; Foster and Schiel 1985; Murray and Bray 1993). These overgrazed areas can persist because high densities of urchins are capable of surviving in a near-starvation state while consuming any edible plants that settle from the plankton (Carroll et al. 2000). Urchin barrens have become increasingly common during the past two decades at the Channel Islands coincident with the long-term warming period accompanied by numerous El Niño events and unusually powerful storms (Engle unpublished data).

The location and extent of kelp beds in the SCB have been determined at various times through aerial photographic surveys by commercial harvesters, BLM, Department, and others (Crandall 1915; Hodder and Mel 1978; Kelco unpublished maps; Neushul 1981). Locations supporting kelp generally have been consistent through time, but the extent of these beds has varied considerably. The physical settings for kelp habitats around the Channel Islands are more variable than mainland locations (Hodder and Mel 1978). Extent of wave exposure, substrate types, and slopes vary extensively. Water clarity is better at the islands, thus kelp ranges into deeper water compared to the mainland. The greater habitat heterogeneity at the islands has resulted in greater kelp forest species diversity compared to mainland kelp beds (Murray and Bray 1993).

4.3.2.4 Surfgrass and Eelgrass Habitat

There are two types of marine flowering plants found in the project area consisting of four species. Surfgrass (*Phyllospadix spp*.) and eelgrass (*Zostera spp.*) are commonly confused due to their similar appearance. Each forms dense beds though on different substrate and in different conditions.

Surfgrass (*Phyllospadix spp*.)

Surfgrass, unlike the eelgrass *Zostera* (often confused with surfgrass), which grows in quiet-water mud or sand habitats, attaches by short roots to rock on surf-swept shores from the low intertidal zone to depths of 10 to 15 meters. This 0.5 to 2 meters tall, emerald green grass commonly occurs in dense perennial beds formed primarily by vegetative growth from spreading rhizomes. Two species (*P. torreyi and P. scouleri*) overlap in geographical distribution and morphological characteristics (Dawson and Foster 1982). *P. torreyi* generally has longer (1 to 2 meters), narrower (1 to 2 millimeters) leaves, longer flower stems with several spadices (floral spikes), and occurs more in semi-protected habitats as well as in deeper water. *P. scouleri* tends to have shorter (less than 50 cm), broader (2 to 4 mm) leaves, shorter flower stems with 1 to 2 spadices, and is found more often in wave-swept intertidal areas (Figure 4-4).

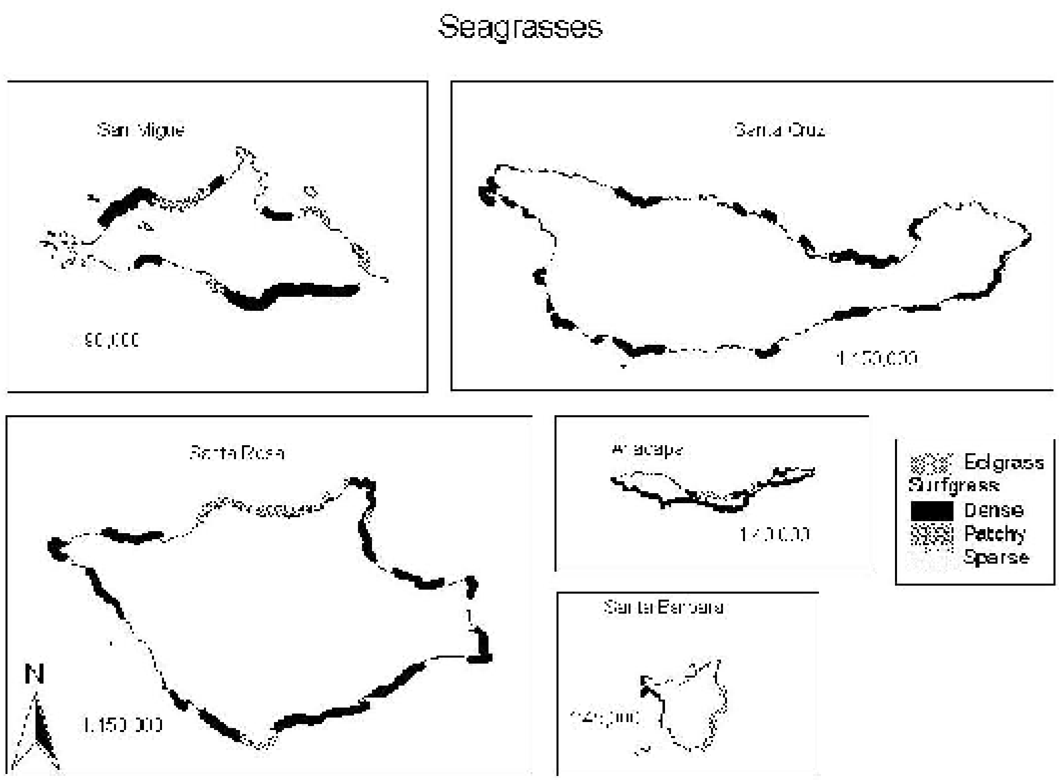

Figure 4-4. Distribution of seagrasses within the project area.

Surfgrass beds are highly productive ecosystems, providing structurally complex microhabitats for a rich variety of epiphytes, epibenthos, and infaunal species. Stewart and Myers (1980) identified 71 species of algae and 90 species of invertebrates associated with surfgrass habitats in San Diego. Some organisms, such as the red algae *Smithora naiadum* and *Melobesia mediocris*, are exclusive epiphytes on surfgrass (or eelgrass) (Abbott and Hollenberg 1976). Also, *Phyllospadix spp.* beds provide nursery habitat for various fishes and invertebrates, including the California spiny lobster

(*Panulirus interruptus*) (Engle 1979). Spiny lobster juveniles shelter in the thicket of leaves and forage on a variety of tiny snails and clams.

Surfgrass beds are persistent (Turner 1985) and can preempt space from other plants, including boa kelp (Black 1974) and sargassum weed (Deysher and Norton 1982). Surfgrass cannot tolerate much heat or drying; the leaves will bleach quickly when midday low tides occur during hot, calm-water periods. Surfgrass can be particularly sensitive to sewage discharge (Littler and Murray 1975) and oil pollution (Foster et al. 1988). Recovery can be relatively rapid if the rhizome systems remain functional, but it might take many years if entire beds are lost because recruitment is irregular and must be facilitated by the presence of perennial turf algae to which surf grass seeds attach (Turner 1983, 1985). Transplant projects undertaken to speed recovery of *Phyllospadix spp.* beds destroyed by shoreline construction have been largely unsuccessful.

<u>Eelgrass (*Zostera spp.*)</u>

Eelgrass is the second type of flowering plant that grows within the project area. Eelgrass beds are known to be ecologically important for primary production, nutrient cycling, and substrate stabilization (Phillips 1984). They provide habitat and food for a unique assemblage of plants, invertebrates, and fishes (den Hartog 1970; McConnaughey and McRoy 1979; Phillips 1984). Eelgrass grows worldwide in quiet, temperate-water mud or sand habitats, especially in bays and estuaries from the low tide level down to 6 meters. It also occurs on sheltered substrates on the open coast to depths of 18 to 30 meters. The shallow limit for *Zostera* is generally determined by wave action while the deep limit is determined by light limitations (den Hartog 1970; Phillips 1984). Open coast subtidal *Zostera* beds have not been well studied, but extensive literature exists for embayment meadows (den Hartog 1970 and Phillips,1984 for overviews). Eelgrass produces seeds that may drop nearby or can be carried by floating flower stalks to distant locations. The viability of seeds can be low and successful recruitment to new habitats relatively rare (den Hartog 1970; Phillips 1984). Once established, *Zostera* patches can expand through vegetative growth along extended rhizomes to form vast meadows.

All eelgrass throughout California was considered to be *Zostera marina* until Phillips and Echeverria (1990) reported *Z. asiatica* along the mainland coast from Tomales Bay to Santa Monica. Typical characteristics of *Z. marina* include: presence at depths less than 5 meters, leaf width 1 to 12 mm, leaf tips obtuse, seeds ridged, March flowering, and seeds present May to June. In contrast, *Z. asiatica* characteristics include: 5- to 17-meter depths, leaf width 12 to 18 mm, leaf tips notched, seeds smooth, August flowering, and seeds present September to October. However, characteristics for the two species are variable and intergrade such that species designation is difficult and subject to continuing scientific debate.

At the Channel Islands, a total of 278 species (and higher taxa) were identified from eelgrass beds, not including most infaunal species, species requiring laboratory identification, or minute species (Engle et al. unpublished data). The diversity of conspicuous plant, invertebrate, and fish epibiota was nearly twice as high within eelgrass beds (approximately 150 species) as on surrounding sand habitats (approximately 80 species).

Important invertebrates include sea anemones, worms, crabs, snails, clams, and seastars. Some species are obligate dependents on *Zostera*. In the Channel Islands the brown alga

Punctaria occidentalis, the flatworm, *Phylloplana viridis*, the sea hare, *Phyllaplysia taylori*, and the limpet, *Tectura depicta*, are epiphytes unique to *Zostera*. The red algae, *Smithora naidum* and *Melobesia mediocris*, also occur on eelgrass and surfgrass (*Phyllospadix spp*.). The isopod, *Idotea resecata*, pipefish, *Syngnathus sp.*, and giant kelpfish, *Heterostichus rostratus*, can occur with other plants, but they are closely associated with eelgrass, often appearing grass green in color. *Zostera* meadows are nursery habitats for a variety of fishes, including bottom-dwellers (e.g., flatfishes and gobies) and epibenthic swimmers (e.g., clinids, seaperches, and basses). Eelgrass beds at the Channel Islands are host to schools of juvenile fishes, especially giant kelp fish, surf perches, senoritas, olive rockfish, and kelp bass (Engle et al. unpublished data).

Eelgrass habitats are vulnerable to oil spills, but the impacts are not well understood. Unlike slime-producing algae that can slough off oil, eelgrass has non-mucilaginous leaves to which oil quickly adheres. Jackson et al. (1989) reported substantial oil effects on tropical grass beds of Panama; however, Dean et al. (1996) found neither acute nor sub-lethal effects on Alaskan eelgrass. Adverse effects on invertebrate communities associated with eelgrass beds have been documented more clearly: hydrocarbons were most persistent, recovery longer, and injury levels higher in eelgrass habitats of Alaska (Dean et al. 1996). Other threats to eelgrass meadows include pollution, habitat disturbances from development (e.g., changes in sediment runoff and water clarity, piers, moorings), cumulative impacts from boat anchors, and overgrazing by sea urchins.

Eelgrass has been found at 10 locations around the Northern Channel Islands at depths of 3 to 15 meters, but it is unclear which species is present because their characteristics intergrade (Engle et al. in press). The *Zostera* sites occur on both north and south sides of the islands in coves sheltered from west and northwest swells. The largest beds (approximately 3 to 12 hectares) occur at Smugglers Cove, Canada del Agua, and Prisoners Harbor on Santa Cruz Island and at Bechers Bay on Santa Rosa Island. Moderate beds (approximately 0.3 to 0.7 hectare) are found at Scorpion and Forney Coves on Santa Cruz Island and at Johnsons Lee on Santa Rosa Island. A few small patches of eelgrass exist at Cathedral Cove and Cat Rock on Anacapa Island and at Yellowbanks Anchorage on Santa Cruz Island. The single patch at Cathedral Cove is the only known remnant of once widespread beds scattered along the north side of Anacapa Island.

4.3.2.5 Water Column Habitats

The water column habitat can be subdivided into the epipelagic, mesopelagic, and bathypelagic zones (Cross and Allen 1993). Light penetration, water temperature, and water mass structure define vertical zonation.

Epipelagic habitats in the Channel Islands extend to depths of 328 feet (100 meters). This zone is euphotic, and temperatures fluctuate diurnally and seasonally. It is approximately 50 meters deep in turbid nearshore waters and expands offshore in clear oceanic waters (Cross and Allen 1993). The epipelagic zone is inhabited by epipelagic fishes that migrate to the surface waters at night (nyctoepipelagic), bottom-associated species that feed in the water column (nektobenthic) (Horn 1980), and the eggs and larvae of most pelagic and demersal fishes (Loeb et al. 1983).

The mesopelagic zone is characterized by steep environmental gradients. It extends from the permanent thermocline below the compensation depth to the 6-degree C isotherm at 500 to 600 meters (Cross and Allen 1993).

The bathypelagic zone is characterized by uniformity and extends nearly to the bottom. It is absent or restricted in the nearshore basins and expands offshore (Cross and Allen 1993).

4.3.2.6 Essential Fish Habitat (EFH)

The Pacific Fishery Management Council (PFMC) manages 93 species of fish under three Fishery Management Plans: 1) Coastal Pelagic Species Fishery Management Plan, 2) Pacific Salmon Fishery Management Plan, and 3) Pacific Groundfish Fishery Management Plan. The Magnuson-Stevens Act defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." National Marine Fisheries Service guidelines state that "adverse effects from fishing may include physical, chemical, or biological alterations of the substrate, and loss of, or injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem." The EFH has been established for five species of coastal pelagics: Pacific sardine, Pacific mackerel, northern anchovy, jack mackerel, and market squid which is from the coast out to the edge of the Exclusive Economic Zone (EEZ) between the U.S. to Canada and U.S. to Mexico borders.

The EFH also has been established for 83 species of groundfish. EFH for Pacific Coast groundfish is defined as the aquatic habitat necessary to allow for groundfish production to support long-term sustainable fisheries for groundfish and for groundfish contributions to a healthy ecosystem. Descriptions of groundfish fishery EFH for each of the 83 species and their life stages result in over 400 EFH identifications. When these EFHs are taken together, the groundfish fishery EFH includes all waters from the mean higher high water line and the upriver extent of saltwater intrusion in river mouths, along the coast of Washington, Oregon, and California seaward to the boundary of the EEZ. The seven "composite" EFH identifications are as follows: estuarine, rocky shelf, non-rocky shelf, canyon, continental slope/basin, neritic zone (33 feet and shallower), and the oceanic zone (66 feet and deeper). Life history and habitat needs for the 82 species managed under the groundfish FMP are described in the EFH appendix to Amendment 11, which is available online at http://www.ner.noaa.gov/1sustfsh/efhappendix/page1.html and is incorporated by reference.

The EFH has been established for five species of salmon: chinook, coho, chum, pink, and sockeye. The EFH for these salmon include those waters and substrate necessary for salmon production to support a long-term sustainable salmon fishery. The EFH includes all streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon. In the estaurine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within State territorial waters out to the full extent of the EEZ.

Habitat Areas of Particular Concern (HAPC) are described in the regulations as subsets of EFH which are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Currently, only Amendment 14 to the Pacific Coast Salmon Plan has addressed HAPC for chinook, coho, and pink salmon.

4.3.3 Biological Resources and Species of Interest

The Marine Reserves Working Group (MRWG) produced a list of “Species of Interest” within the project region. Various criteria were developed to determine if species should be included. The criteria included:

1. species of economic and/or recreational importance
2. keystone or dominant species
3. candidate, proposed, or species listed under the Endangered Species Act
4. species which have exhibited long-term or rapid declines in harvest and/or size frequencies
5. habitat-forming speices
6. indicator or sensitive species
7. important prey species

The entire list of 119 species is detailed in Appendix 4. For each species on the list information on distribution, habitat, diet, regulations, and criteria for listing are given.

4.3.3.1 Plankton

<u>Phytoplankton</u>

Phytoplankton, are single cell or colonial algal species, range in size over three orders of magnitude (Siebruth 1979). Phytoplankton can be classified according to size: very small species (autotrophic bacteria) are classified as picoplankton (0.2 to 2 micrometers), most are classified as nanoplankton (2 to 20 micrometers) or microplankton (20 to 200 micrometers), and a few large species as mesoplankton (0.2 to 20 millimeters) (Hardy 1993).

Phytoplankton form the base of the food web; they support grazing zooplankton, fish, and, through their decay, large quantities of marine bacteria. The success of zooplankton depends upon both the quantity and quality of their phytoplankton food supply (Dailey et al. 1993). For example, the fecundity (egg production) of zooplankton depends upon the nutritive value (nitrogen content) of the phytoplankton on which they feed (Checkley 1980a,b). Fish production, in turn, is highly dependent on the growth and productivity of phytoplankton and zooplankton (Ryther 1969). The success of larval fish and their subsequent recruitment into the adult fish population often depend upon spatial and temporal concurrence of fish larvae with an abundance of their plankton food source (Mullin et al. 1985).

Many species of phytoplankton inhabit the the project area. Their relative abundance in terms of numbers, biomass, and production varies greatly both spatially and temporally. The two most abundant and important components of the phytoplankton community are generally the diatoms (bacillariophytes) and the dinoflagellates (pyrrophytes).

The community of larger (greater than 50 mm) phytoplankton in the project area includes a broad range of temperate water forms as well as forms that characteristically occur in either warmer or colder water. This diversity reflects the general transitional nature of the Channel Island’s flora, which results from the physical oceanographic and mixing characteristics of the region. For example, incursions of exceptionally warm water currents in the area generally bring with them warm water species.

Seasonal and geographic variations in nanoplankton are remarkably stable, and variations in plankton productivity are due primarily to the larger micro plankton. The coastal zone color scanner (CZCS) on the Nimbus 7 satellite has provided useful information on the distribution of phytoplankton by measuring chlorophyll over extensive areas of the Southern California Bight. Such data provide synoptic views of complex oceanographic regions, which are impractical to obtain from ships alone. Satellite imagery has also allowed the identification of persistent and striking biological features. Many of these recurring large-scale patterns were either unknown or only dimly perceived prior to the advent of satellite imagery. For example, Nimbus 7 CZCS imagery revealed the occurrence far offshore of a large region of high phytoplankton pigment, a biological "hot spot" that loosely overlies a system of submarine ridges, banks, and basins that make up the Continental Borderland. Also, shallow basins and enclosed shallow areas such as the Santa Barbara Channel consistently show high pigment content, with an approximately threefold change in phytoplankton pigment content over a distance of a few kilometers. These large-scale structures undergo significant monthly, seasonal, and annual changes although the large-scale pigment patterns for a given season tend to reappear from one year to another (Pelaez and McGowan 1986).

Numerous measurements of primary production, which is the photosynthetic conversion of inorganic carbon to organic cellular material by phytoplankton, have been conducted in the SCB. The efficiency of conversion of solar energy into organic matter in the SCB has been estimated to be well under 1 percent (Eppley and Holm-Hansen 1986).

Environmental factors regulating growth lead to a complex spatial and temporal pattern of phytoplankton and productivity in the region. Every point in the water column is basically unique with regard to such variables as light intensity, nutrient mixture and concentration, and temperature. Small-scale biomass patchiness occurs even on scales of less than 1 meter (Hardy 1993). Physical factors of mixing and currents also determine the distribution of phytoplankton. Each species differs in its unique physiological requirements and optima for both light and nutrients. Topographic features of the SCB such as the complex of offshore islands and banks, which run from Santa Rosa and San Nicolas south to Tanner and Cortes banks, impose additional heterogeneity (Hardy 1993).

As is typical of California, plankton abundance and primary production in the SCB are generally higher nearshore than offshore. Since the continental shelf is only a few kilometers wide, internal waves from deep water typically move shoreward, injecting nutrient-rich water onto the shelf area. Also, episodic sediment disturbance and suspension are important mechanisms of nutrient regeneration in the shallow nearshore area (Fanning et al. 1982). Significant differences in longshore abundances of phytoplankton species occurred between the north and south parts of the SCB. Out of 45 cases tested, 19 had greater abundances in the south. Only three species had greater abundances to the north (Cullen et al. 1982). In addition to horizontal patterns, the abundance of individual species, total biomass, and productivity of phytoplankton generally show marked differences vertically through the water column (Hardy 1993).

Temporal patterns can be divided into short-term "events" on a scale of hours, days, or a few months and longer term seasonal or recurring annual trends. Like other areas, the Channel Islands can experience blooms (dense growths and accumulations of phytoplankton). Short-term blooms of diatoms and other phytoplankton associated with upwelling events often occur in winter or spring and last for a few days to a few weeks. A typical year has three such blooms each lasting 5 to 6 weeks (Tont 1976). The variance in abundance of phytoplankton between bloom and non-bloom periods can be almost as great as the annual variation in abundance (Tont and Platt 1979).

In general, diatoms have several major peaks of abundance that are 5 to 6 weeks in duration, usually during the first half (but occasionally the latter half) of each summer (Tont 1976, 1981; Tont and Platt 1979). A high correlation in the occurrence of blooms was generally observed between San Diego and Port Hueneme, although the dominant species in the two locales were frequently different. The majority of these blooms occurred in conjunction with upwelling events. Sea surface temperature decreases of 2.5 C indicating upwelling were often associated with diatom standing stock increases of four orders of magnitude (Hardy 1993).

The biomass of the larger diatoms tends to be maximal in late winter or spring although fall blooms also occur (Allen 1936). Large dinoflagellates tend to bloom in summer and slightly earlier at La Jolla than at Port Hueneme, but winter blooms are also known (Allen 1941). Unlike at La Jolla, phytoplankton densities at Port Hueneme show seasonal variations that exceed the variability on shorter time scales (Tont and Platt 1979).

Under certain oceanographic conditions, blooms are dense enough to alter the color of the water to red, yellow, green, or brown (Oguri et al. 1975). Although these blooms can be caused by different groups of organisms, including diatoms, they are most commonly caused by dinoflagellates (Hardy 1993). Although not related to the tidal cycle, blooms of red-pigmented dinoflagellates are called red tide. Red tides can occur in the Sanctuary almost any month of the year and are generally most pronounced nearshore (Oguri et al. 1975). Spring red tide blooms are dominated by *Prorocentrum micans* while the more intensive and frequent blooms during July through October are dominated by *Gonyaulax polyhedra* (Sweeney 1975).

<u>Zooplankton</u>

Zooplankton of the region comprise a large and diverse group of animals. This section will address the interrelationships between the distribution and abundance of these organisms and the oceanography that influences these distributions.

Roseler and Chelton (1987) summarized CalCOFI zooplankton data (displacement volumes) over a 32-year period from 1951 to 1982. They noted that non-seasonal zooplankton variability was dominated by very low-frequency patterns with periods of 3 to 5 years that are associated with variations in large-scale equatorward transport of the California Current. Years when California Current flow was higher than normal were associated with larger zooplankton biomass of 3 to 4 months' duration.

McGowan et al. (1998) note that zooplankton biomass has decline over 70 percent since the late 1970s in concert with increasing sea surface temperature. This interannual variable should be considered the baseline for understanding higher frequency events and processes, including biological interactions. These smaller scale, higher frequency processes include seasonal changes and localized events such as coastal upwelling, eddies, plumes, tidal oscillations, bottom processes, diel cycles, wind stress, and turbulence. The extent to which these physical events control or modify zooplankton ecology is a function of the particular organism, including its size, swimming ability, reproductive state, food needs, and other requirements (Dailey et al. 1993).

The three zones designated for zooplankton are harbor and bay, nearshore (shelf and shelf break), and offshore (open ocean and basins). The spatial distribution of the dominant zooplankton reflects the environmental characteristics of the zone's waters (Dailey et al. 1993).

The nearshore zone, which encompasses those waters shoreward of the continental shelf slope break or approximately the 200-meter depth contour, is a useful demarcation for study of zooplankton since the water over the continental shelf tends to be an area of high productivity. This augmented region of productivity (Ryther 1969) is usually associated with increased vertical mixing and, thus, greater nutrient recycling and upwelling, both of which are wind-forced phenomena. The maintenance of a shelf zooplankton assemblage is largely dependent on the physical width of the shelf as well as on the frequency of offshore advection over the shelf.

Microzooplankton are those animals feeding on particulate organic sources; they comprise protozoan as well as juvenile stages of larger zooplankton. Protozoans account for the greatest percentage of the microzooplankton numerically while the micrometazoans dominate the biomass (Beers and Stewart 1967, 1969a, b, 1970). Because of their high reproductive capacities relative to the metazoans, protozoans have a markedly more important effect on the dynamics of the pelagic trophic web. Since protozooplankton can reproduce by simple asexual binary fission, they are able to respond rapidly to a changing environment. In addition, because generally higher physiological rates are found among small organisms, they are considered by Beers (1986) to be among the most important pelagic herbivores, a role generally reserved for copepods in the past. Beers and Stewart (1969b, 1970) have shown that the biomass of the microzooplankton is generally 20 to 25 percent of the total larger macrozooplankton, both inshore and offshore in the SCB.

The macrozooplankton are a diverse group of animals composed of a number of major taxonomic categories. The medusae, ctenophores, and planktonic molluscs and tunicates are sometimes grouped into what is commonly termed gelatinous zooplankton. The chaetognaths (arrowworms) are important carnivorous zooplankters, but the majority of the zooplankton are made up of crustaceans, mostly copepods. Planktonic copepods are primarily calanoids. Of the calanoid copepods, *Acartia, Paracalanmus, Labidocera*, and *Calanus* are the most common genera collected nearshore in the SCB (Barnett and Jahn 1987).

Regarding offshore zooplankton, a number of investigators (Eppley et al. 1979) have maintained that for eastern boundary currents, including the California Current, wind-drive coastal upwelling is the main source of new nutrients entering the euphotic zone. Others (Reid 1962; Bernal and McGowan 1981; Roesler and Chelton 1987) have found a correlation between zooplankton biomass, cold water temperature, and increased flow of the California Current. Chelton et al. (1982) analyzed 30 years of CalCOFI data to determine which of these factors plays the dominate role in California Current zooplankton biomass fluctuations. They compared the longshore component of wind stress with mean monthly zooplankton volumes and concluded that, while wind-induced upwelling may play some role in zooplankton fluctuations, instead fluctuations are more related to changes in the transport of the California Current in the SCB.

Beers and Stewart (1969b) found a gradient of decreasing microzooplankton from onshore to offshore in the SCB. They also found an increasing concentration of microzooplankton relative to the concentration of chlorophyll-a with distance offshore, and they suggested that the microzooplankton may play a more significant role in the offshore than in the nearshore realm.

Macrozooplankton of the offshore zone often comprise many of the same species as found nearshore. In addition to these, more oceanic and deeper water species have been collected. Of the calanoid copepods, *Calanus, Pleuromanmma*, and *Metridia* are common offshore genera in the SCB (Dailey et al. 1993).

Although it contains some unique species, the SCB is largely a transition zone between subarctic, central, and equatorial species. Thus, biomass fluctuations may also be accompanied by changes in species composition. The boundary (or clinal region) between cold, nutrient-rich California Current water (and its associated subarctic species) can vary in position relative to warmer, nutrient-poor water from the south (equatorial water) and west (central water) (Dailey et al. 1993).

4.3.3.2 Macroalgae and Vascular Plants

The northern Channel Islands include a wide variety of marine plants due to its transitional location between cold- and warm-water biogeographic provinces and its diversity of coastal environments, ranging from sheltered embayments to exposed open coast mainland and island habitats (Abbott and Hollenberg 1976; Murray et al. 1980). Most marine macrophytes require hard substrate for attachment, and all need light for photosynthesis, thereby largely restricting their depth distribution to the upper 50 meters or less depending on water clarity. In the SCB, 492 species of algae and 4 species of seagrasses are known to occur out of the 673 species described for California in Abbott and Hollenberg (1976) (Murray and Bray 1993). Of the 492 species, 59 are green algae (Chlorophyta), 86 are brown algae (Phaeophyta), and 347 are red algae (Rhodophyta).

Knowledge of the distribution and abundance of marine plants in the SCB has expanded considerably since the mid-seventies, largely due to the quantitative intertidal surveys conducted by the BLM from 1975 to 1979 (Littler 1980; Littler et al. 1991). The results of these and other studies are summarized in Murray and Bray (1993). During the 1980s and 1990s, surveys by Channel Islands National Park, MMS, Tatman Foundation, and others focused on monitoring population dynamics of key species at representative regional sites (Dunaway et al. 1997). The University of California Santa Barbara (UCSB) has research projects targeting surfgrass (*Phyllospadix*) (Read et al. unpublished data) and boa kelp (*Egregia*) (Blanchette et al. unpublished data). Most research on subtidal plants has concentrated on giant kelp forest communities (Foster and Schiel 1985). Much less is known about other subtidal macrophyte assemblages, despite the importance of plant-dominated habitats for a multitude of invertebrates and fishes. Reconnaissance and monitoring surveys focused on the islands have been carried out by CINP-KFMP (CINP 1982 to 1997) and the Tatman Foundation Channel Islands Research Program (CIRP 1980 to 1998). Subtidal eelgrass (*Zostera*) habitats at the islands were investigated recently for the California Coastal Commission (Engle et al. unpublished data).

Northern species are defined here as ranging northward from northern Baja California (at about Bahia del Rosario) into and often beyond the Oregonian Province. Southern species, on the other hand, range southward from central California (in the Monterey area) into and, less commonly, through the Californian Province. Transitional species are narrowly defined as endemics restricted to the region of overlap, i.e., between northern Baja California and central California. Species classified as widespread range broadly to the north and south of southern California; at a minimum, through the Californian and Oregonian Provinces between central Baja and northern California.

Species distributions from BLM surveys (Murray and Bray 1993) and more recent surveys confirm that the northern Channel Islands encompasses the transition between southern, warm-water Californian flora and northern, cold-water Oregonian flora. The Channel Islands are particularly transitional, with each island having its own mix of southern versus northern species. Although conditions are dynamic, the general pattern is that Santa Barbara Island is most favored by southern species, Anacapa and Santa Cruz Islands are most intermediate with both southern and northern components, while Santa Rosa and San Miguel Islands are more populated with northern species. This north/south species gradient also was obvious for intertidal algae surveyed along the mainland from Point Conception south to San Diego for the BLM program (Murray and Littler 1981). Three groupings were evident: (1) sites nearest Point Conception, (2) sites from the Santa Barbara Channel south to Santa Monica Bay, and (3) sites from Los Angeles south to San Diego.

No marine plants in the region are listed or proposed for listing under State or Federal programs for protecting species in danger of extinction. However, some species deserve special consideration because of their importance as keystone species, dominating ecosystems that are defined by their presence. Giant kelp, surfgrass, and eelgrass are described above.

Analyses of past studies indicate that marine plant diversity is greater in the SCB and the Channel Islands than the diversity associated with central California due to the greater variety of habitats present and to mixing of southern and northern species in the SCB. Murray et al. (1980) found that floral diversity in California was positively correlated with decreasing latitude, with maximum richness (446 species) occurring between 33 degrees and 34 degrees north (N) latitude.

Macroalgae

Algae include the macroscopic members of the plant divisions Chlorophyta (green algae), Phaeophyta (brown algae), and Rhodophyta (red algae), often referred to as seaweeds. The Channel Islands include a rich array of flora of benthic macroalgae and seagrasses. The shallow coastal habitats show considerable variation in wave action, ocean water masses, thermal regimes, and substrata. The large coastal area and the degree of habitat heterogeny contribute to the great diversity of macrophytes documented for the SCB (Abbott and Hollenberg 1976; Murray et al. 1980).

A total of 492 species of algae occur in the SCB, including 59 Chlorophyta, 86 Phaeophyta, and 347 Rhodophyta, making the composition of the SCB seaweed flora 70.5 percent red, 17.5 percent brown, and 12 percent green (Murray and Bray 1993).

South of Point Conception, the flora tends to be dominated by shorter, more densely branched species of red algae instead of larger, fleshy forms (Abbott and Hollenberg 1976). Brown algae, especially those in the Order Dictyotales, also become more prominent in southern California subtidal habitats, replacing many of the bladed red algae common to the north.

Murray et al. (1980) suggested that the high diversity of SCB seaweed flora may be related to the greater amount of shoreline habitat found south of Point Conception and to the various exposures of island habitats to the warm and cold ocean currents prevalent in the SCB.

<u>Giant Kelp</u> (*Macrocystis pyrifera*)

Please see section **4.3.2.3 Kelp Forest Habitat** above.

<u>Seagrasses</u>

Please see section **4.3.2.4 Seagrass Habitat** above.

4.3.3.3 Invertebrates

Benthic invertebrates include species from nearly all phyla of invertebrates that live in (infauna) or on (epifauna) the sea floor during most of their lives, though most also have pelagic larvae. They may also be characterized as sessile (attached or sedentary) or motile (free-moving). They range in size from little known microscopic forms (microinvertebrates) to the more common larger organisms (macroinvertebrates). The Channel Islands is characterized by a wide variety of benthic invertebrates due to its transitional location between cold and warm biogeographic provinces and its diversity of substrates. These include sheltered and exposed coasts at depths from the intertidal to deep slopes, canyons and basins (Thompson et al. 1993). The total number of species may well be in excess of 5,000, not including microinvertebrates (Smith and Carlton 1975: Straughan and Klink 1980).

Macroinvertebrates have been studied to varying degrees in representative habitats throughout the region. Ecological relationships are best known for invertebrates from intertidal and shallow subtidal environments because of their accessibility. However, there has been relatively little emphasis in the past two decades on species inventories or compiling species information from various individual nearshore projects. More emphasis has been placed on monitoring population dynamics of key rocky intertidal and kelp forest species by government agencies such as CINP, MMS, CCC, and Santa Barbara County (Dunaway et al. 1997; Engle 1994; Engle et al. 1997).

A major source for regional species distributional data is the BLM baseline survey program conducted in 1975 to 1979, which included intertidal and deep-water (but not shallow-water) habitats. Straughan and Klink (1980) compiled a taxonomic listing of the common nearshore species from southern California as part of the BLM program, including approximately 300 cnidarians, 60 nemerteans, 575 polychaetes, 1,100 mollusks, 20 pycnogonids, 250 crustaceans, 5 stomatopods, 20 tanaids, 30 cumaceans, 125 isopods, 300 amphipods, 20 sipunculids, 10 echiurans, 150 echinoderms, and 50 ascidians. Other major sources for deepwater invertebrate species inventories include surveys carried out for coastal waste treatment and other outfall monitoring programs and studies sponsored by MMS to evaluate possible impacts of offshore oil and gas operations. The Southern California Association of Marine Invertebrate Taxonomists

(SCAMIT) compiled an extensive, standardized list of macro- and mega-invertebrates from SCB mainland soft-bottom habitats at depths from 10 to 300 meters (SCAMIT 1998). Although most of the species records were from outfall studies, other randomly sampled sites were included as part of the Southern California Bight Pilot Project (SCBPP) (Allen et al. 1998; Bergen et al. 1998). Additional records for the Channel Islands will be available when 1998 SCBPP data are released. These largely unpublished data were compiled primarily from reconnaissance surveys at the Channel Islands during the 1980s and 1990s conducted by the Tatman Foundation CIRP. Other data were included from CINP, CCC, and MMS surveys. Records from the 1975 to 1978 BLM program were not included.

Species distributions from BLM surveys (Seapy and Littler 1980, 1993; Thompson et al. 1993) and more recent surveys confirm that the Channel Islands encompasses the transition between southern, warm-water Californian fauna and northern, cold-water Oregonian fauna. The Channel Islands are particularly transitional, with each island having its own mix of southern versus northern species. Although conditions are dynamic, the general pattern is that Santa Barbara Island is mostly composed of southern species, Anacapa and Santa Cruz Islands have both southern and northern components, while Santa Rosa and San Miguel Islands have northern species.

The white abalone, which was recently Federally listed as endangered, is the only invertebrate species currently listed under either State or Federal Endangered Species Acts although the black abalone has recently been listed as a candidate species for Federal listing. A number of invertebrate species deserve special consideration because of their importance as keystone dominants, harvested species, or species particularly sensitive to environmental impacts. These species are highlighted below.

<u>Corals</u>

California hydrocoral (*Stylaster californicus* (= *Allopora californica*)). Spectacular, but little known California hydrocoral colonies inhabit subtidal depths (known to 96 m) from Vancouver Island (Canada) to central Baja California. Hydrocoral colonies occur on current-swept rocky reefs and pinnacles (Engle and Coyer 1981; Osterello 1973). These purple or pink-red hydrocorals resemble small branching tropical staghorn coral (to 53 centimeters). Sessile, filter-feeding adults produce planktonic larvae with limited dispersal. Slow-growing (approximately 0.8 centimeters per year) colonies may live well over 30 years. At least four obligate commensals are supported by the hydrocoral colonies: two polychaetes, one snail, and one barnacle (Osterello 1973; Wright and Woodwick 1997).

Since this hydrocoral keeps its purple color when dried, it has been commercially harvested in the past for sale in shell shops. The fishery is presently closed. The slow growth and limited dispersal of the California hydrocoral suggests that it may be particularly sensitive to disturbance and fishery pressure. Colony branches are easily broken by anchors and divers. California hydrocoral has no known predators (Osterello 1973). However, colonies are susceptible to overgrowth by algae or smothering by sedimentation (Morris et al. 1980; Osterello 1973; Thompson et al. 1993). California hydrocoral is rare, at least within scuba diving depths, and is especially rare in the Sanctuary. Here it is known from only a few deep, current-swept reefs at Santa Barbara, Santa Cruz, and San Miguel Islands (Engle unpublished data). Its abundance in deepwater is largely unknown although BLM surveys assessed abundances at Tanner and Cortes Banks, south of San Nicolas Island.

Ridgeback prawn (*Sicyonia ingentis*).

Ridgeback prawns occur in subtidal depths (48 to 175 meters) from Monterey Bay to central Mexico. Preferred deep-water habitats are sand, shell, and mud substrates (Leet et al. 1992). These prawns are identified by a prominent ridge along the dorsal midline of the abdomen and a short rostrum. Adult prawns are relatively sedentary. The diet is not well known, though it is suspected to be a detritus feeder as are related prawns. This species may live about 5 years. A commercial fishery using trawling gear began in 1966. Landings decreased dramatically from 1985 to 1991 1991 (population decline confirmed by Department surveys at that time), but have since increased to over 1.4 million pounds in 1999 (Leet et al. 1992, 2001; Thompson et al. 1993). Surveys by the Department confirmed population declines since 1985.

Spot prawn (*Pandalus platyceros*).

Spot prawns occur in deep water (50- to 533-meter depths) from Alaska to San Diego. These prawns are reddish-brown with two prominent posterior white spots and 3 to 4 longitudinal white stripes on their carapace. They may be associated with hard or soft substrates. The diet of spot prawns consists of small crustaceans, plankton, mollusks, polychaetes, sponges, and carcasses (O'Clair and O'Clair 1998). This species may live for more than 6 years. A commercial fishery using trawling gear and traps began in the Channel Islands area in 1974 (Leet et al. 1992). State-wide landings increased steadily from 1984 to nearly 800,000 pounds in 1998 with a drop to 600,000 pounds in 1999 (Leet et al. 2001).

Spiny lobster (*Panulirus interruptus)*

California spiny lobster inhabit low intertidal levels to subtidal depths (to 80 meters) from Monterey Bay to central Mexico, but they are rare north of Point Conception. These warm-water crustaceans are identified by their long antennae, reddish-brown color, and large size (to 60 centimeters). Juveniles (under 2 years) utilize shallow vegetated reefs, especially surfgrass beds as nursery habitats (Engle 1979). Adults inhabit crevices in rocky areas, from which they emerge at night to forage on a wide variety of invertebrates, including worms, mollusks, and sea urchins. Spiny lobsters may live 30 years or more (Leet et al. 1992). Spiny lobsters occur at all of the Channel Islands, but are more abundant in those locations in the Californian and Transition Zones.

Spiny lobsters have been commercially harvested using traps in California for over 100 years. Most of the fishery is in water less than 30 meters deep although the fishery has expanded to include deeper habitats. A sport fishery (hand capture) is popular among scuba divers in the Channel Islands area. Other sources of mortality include predation by octopus and fishes. California spiny lobster populations have not been well studied; however, population levels appear to be fairly stable, possibly maintained by recruitment from Baja California facilitated by warm-water patterns over the past two decades (Engle 1994). Landings declined from 1950 to 1975, then increased coincident with establishment of escape ports for sublegal lobsters in traps and development of the long-term warming trend (Leet et al. 1992). During the 1990's landings generally ranged from 600,000 to 800,000 pounds with a peak of 950,000 pounds in 1998, then fell about 500,000 pounds in 1999. Landings in this fishery are strongly influenced by weather, oceanographic conditions and the export market (Leet et al. 2001).

Crabs

Crabs are primarily benthic arthropods of the Class Brachyura. There are many species, with varying ecological niches. Three major groups of crabs occur in the region, each with multiple species: spider, cancroid, and grapsoid crabs. Three species of cancroid crabs are of particular interest.

Rock crabs: Brown rock crab (*Cancer antennarius*), yellow rock crab (*C. anthonyi*), and red rock crab (*C. productus*).

Rock crab species inhabit low intertidal levels to subtidal depths (less than 40 meters). The brown rock crab occurs from Washington to central Baja California. The yellow rock crab occurs from northern California to southern Baja California. The red rock crab occurs from Alaska to central Baja California. Yellow rock crabs prefer soft substrate habitats while brown and red rock crabs prefer rocky substrata. Rock crabs have smooth carapaces, dorsal shell colorations matching their name, and a yellow underside. Migration is unknown, though they do randomly range over several kilometers. Rock crabs are predators (feeding on a wide variety of invertebrates) and scavengers. They may live about 6 years or more (Leet et al. 1992).

Large-scale commercial harvest of rock crabs using traps began in 1950. Santa Barbara and the Channel Islands represent major fishery areas. A minor sport fishery, using hoop nets and star traps, exists. Rock crab landings steadily increased through 1984 to over 2 million pounds and have since declined to 700,000 pounds in 1999 with some fluctuation (Leet et al. 2001). Other sources of mortality include predation by fishes, octopus, sea stars, and sea otters. Rock crab populations in the region have not specifically been assessed; however, experimental trapping has shown that catches are lower in commercially targeted areas (Gotshall and Laurent 1979; Leet et al. 1992; Morris et al. 1980).

Abalone

Seven species and one sub-species of abalone are found in the Channel Islands. All species are mollusks of the Family Haliotidae, genus *Haliotis*, that adhere with an enlarged foot to rocky substrata, and feed primarily on drift algae. Five species of abalone (black, green, pink, red, and white) were popular sport and commercial species until populations experienced severe declines during the 1980s and 1990s. These declines likely resulted from a combination of overharvest, disease, and a long-term warming trend leading to poor recruitment coincident with enhanced storm activity, reduced kelp abundance, and increased competition with sea urchins (Leet et al. 1992; Engle 1994). The taking of abalone has been prohibited in California since 1993, except for sport take by free divers in northern California. Mariculture operations supply small red abalone for restaurants. One species, the white abalone, has been listed as endangered and the black abalone is a candidate species for such listing under the Federal ESA. The five major species of abalone in the Channel Islands typically occupy different, but overlapping, depth ranges (Haaker et al. 1986). From intertidal to deepwater, dominant species are black, green, pink, red, and white abalone.

Black abalone (*Haliotis cracherodii*).

Black abalone inhabit mid-low intertidal levels down to shallow subtidal depths (to 6 meters) from Oregon to southern Baja California (Morris et al. 1980). They are readily identified by dark, bluish-black coloration, a smooth shell with 5 to 7 open respiratory holes, and relatively small size (5 to 20 centimeters as adults). Black abalone are relatively sedentary and typically found clustered in wet crevices, under boulders, or on the walls of surge channels along exposed shores. Juveniles graze on diatom films and coralline algae while adults primarily eat drift algae, especially brown kelps. Black abalone compete with sea urchins and other crevice-dwellers for space and food (Miller and Lawrenz-Miller 1993; Taylor and Littler 1979). Where abundant, abalone may be stacked on top of each other, reaching densities of more than 100 per square meter (Douros 1987; Richards and Davis 1993). Black abalone are slow-growing and long-lived, with recruitment apparently being low and variable (Morris et al. 1980; VanBlaricom 1993). Growth rates depend on animal size, location, food availability, reproductive condition, and other factors. Absolute longevity has not been determined, but ages greater than 30 years appear likely based on tagging and other population studies (VanBlaricom 1993).

Although once an important fishery resource throughout the region, landings peaked in 1973 and declined thereafter (Leet et al. 1992). Sport and commercial black abalone fisheries have been closed since 1993. Black abalone populations in southern California suffered catastrophic declines since the mid-1980s that have resulted in nearly complete disappearance of black abalone along mainland shores south of Point Conception (Miller and Lawrence-Miller 1993), as well as at many of the Channel Islands (Lafferty and Kuris 1993; Richards and Davis 1993). Mortality was associated with "withering syndrome" (WS), in which the foot shrinks and weakened individuals lose their grip on rock surfaces (Antonio et al. 2000; Friedman et al. 1997; Gardner et al. 1995). WS or its prokaryotic infection has been observed in abalone north of Point Conception in recent years; however the disease is not widespread (Altstatt et al. 1996). Overfishing also played a role in the population declines. Other sources of mortality include smothering by sand burial, dislodgment by storm waves, and predation by octopus, sea stars, fishes, and sea otters (Morris et al. 1980; VanBlaricom 1993). Impacts from oil are little known, but North et al. (1964) reported black abalone mortality following a spill in Baja California. Because of low recruitment, slow growth, and already reduced reproductive populations, additional mortality from oil spills would further inhibit recovery.

<u>Green abalone</u> (*Haliotis fulgens*).

Green abalone inhabit low intertidal levels to subtidal depths (to 18 meters) from southern California to southern Baja California (Morris et al. 1980). These warm-water abalone are identified by lighter, olive-green to red-brown, shell coloration, a finely ribbed shell with 5 to 7 open holes, relatively small size (usually less than 20 centimeters), and a green and brown mottled foot. Green abalone are relatively sedentary and are commonly found in deep crevices exposed to strong wave action. Adult population density may depend on the availability of suitable crevice habitats. They feed almost exclusively on large drift algae. This species may live 20 years (Leet et al. 1992). Green abalone were an important fishery in California, with landings peaking in 1971 and rapidly declining thereafter (Leet et al. 1992). They were most common at the southern Channel Islands (including Santa Barbara Island) and present at the northern Channel Islands, but are now rarely encountered. The green abalone commercial and sport fishery is currently closed. Sources of mortality include predation by octopus, sea stars, fishes, and sea otters.

Pink abalone (*Haliotis corrugata*).

Pink abalone inhabit subtidal depths (to 60 meters) from southern California to central Baja California (Morris et al. 1980). They are identified by lighter, green or red-brown shell coloration, an irregularly ribbed shell with 2 to 4 open holes, an arched shell with a scalloped margin, relatively small size (usually less than 17 centimeters), and their black and white mottled foot. Pink abalone are sedentary, occupying a permanent scar on a home rock. This species occurs in partially sheltered waters, infrequently dwelling in crevices. They feed almost exclusively on large drift algae. This species may live 20 years (Leet et al.1992).

In the early 1950s, pink abalone comprised the largest segment of the abalone fishery, about 75 percent, and had a significant effect on the total abalone landings. Commercial landings originated at the eastern northern Channel Islands (Anacapa, Santa Cruz), and the southern Channel Islands (San Nicolas, Santa Catalina, Santa Barbara, San Clemente). Because pink abalone are more fragile than others and grow more slowly, the level of take could not continue (Leet et al. 2001). Department research cruises to San Clemente, Santa Catalina, and Santa Barbara Islands in 1996 and 1997, were used to investigate pink, and other, abalones. The number of abalones sighted per unit of time was used to quantify stocks, and a factor was applied to estimate the number of commercially legal pink abalone that could be collected per hour. Estimates ranged from about one to 1.5 abalone per hour. Similar cruises conducted in 1999, estimated only 0.28 commercial legal pink abalone per hour. At Catalina Island, no commercial sized pink abalone were found.

Red abalone (*Haliotis rufescens*).

Red abalone inhabit low intertidal levels to subtidal depths (to 26 meters, rarely to 180 meters) from Oregon to southern Baja California (Morris et al. 1980). They are identified by brick red shell coloration, an irregular shell surface with 3 to 4 open holes, and relatively large size (to 30 centimeters). These colder-water abalone are relatively sedentary on reef tops or in crevices. They feed on drift algae and, especially when young, on microscopic algal films. This species may live 20 years (Leet et al. 1992).

Red abalone were previously an important fishery in California, with landings peaking in 1967 and steadily declining thereafter (Leet et al. 1992). In central and southern California, red abalone had declined the least of all five species by the time the fishery was closed in 1997 (Leet et al. 2001). Combined landings of red abalone declined during the period from 1969 to1982 stabilizing at 1/10 their historic average during the 14 year period before the 1997 closure (Leet et al. 2001). Detailed examination of catch by area and fishery independent assessments reveal that the stability in landings masked ongoing reductions of local populations, as successive areas declined by over two orders of magnitude. From 1952-1968 most red abalone were caught in central California, followed by southern mainland, Santa Cruz, Santa Rosa and San Miguel Islands (Leet et al. 2001). Catches declined first along the central coast under the combined effects of expanding sea otters and fishing pressure. Outside the sea otter range catches declined more slowly along the southern mainland than at Santa Rosa, Santa Cruz, and San Nicolas Islands. From 1983-1996, catch decreased off these three islands to three percent, for Santa Rosa, and less than one percent, for Santa Cruz and San Nicolas, of their respective peak catches by the 1997 closure (Leet et al. 2001). San Miguel Island and the north coast were the exceptions to this pattern. Catches from San Miguel Island, the farthest and most northern of the Channel Islands, and the north coast comprised 71 of the 87 tons landed in 1996 prior to the fishery closure in 1997 (Leet et al. 2001). The red abalone commercial and sport fishery is currently closed, except for sport take by free divers in northern California. Other sources of mortality include predation by crabs, octopus, sea stars, fishes, and sea otters.

White abalone (*Haliotis sorenseni*).

White abalone occur subtidally (about 20 to 65 meters) from southern California to southern Baja California. These southern, deep-water abalone are readily identified by their red-brown shell color, a ribbed shell with 3 to 5 open holes, and a yellow-green and beige mottled foot. They grow to approximately 25 centimeters. Individuals of up to an estimated 25 years of age have been reported (Davis et al. 1996; Gotshall and Laurent 1979). White abalone are sedentary, inhabiting open, exposed deep-water reefs with a kelp understory. Adults consume drifting and attached macroalgae. Juveniles are cryptic, hiding in crevices and beneath rocks where they feed on microalgal films (Davis et al. 1996). The white abalone fishery developed late due to their deep habitats with the first reported commercial landings in1968; however, they were popular because the foot meat is tender. Abundances were highest at the southern and northeastern Channel Islands. Peak landings occurred in 1972 and decreased thereafter (Leet et al. 1992). Average density during periods of peak harvest in the 1970s was one abalone per square meter. Density has dramatically decreased since to 0.002 per square meter (Carlton et al. 1999). Surveys in the Channel Islands area found that density may have further decreased to 0.0001 per square meter (Davis et al. 1998). Since females must be within a few meters of a male during spawning for fertilization to occur, present population densities in the area may preclude successful spawning. Some sections of the white abalone fishery have been closed since 1977 and the entire fishery has been closed since 1993, though densities have continued to fall (Carlton et al. 1999; Davis et al. 1998). Subthreshold breeding density and continued predation (e.g., fish, octopus, and sea stars) suggest that recovery without significant human intervention is unlikely. Submersible surveys were carried out to further evaluate population status and to explore possibilities for collection of specimens for a captive breeding program. The rarity of this species prompted the National Marine Fisheries Service (NMFS) to list it as a candidate species under the Endangered Species Act in 1997. This action required a status review, which concluded that overexploitation was the major cause of the decline. Subsequently, in May 2000, the white abalone became the first marine invertebrate to receive Federal protection as an endangered species.

Limpets

Owl limpet (*Lottia gigantea*).

Owl limpets are common in high and middle tide zones of exposed rocky shores from Washington south to Baja California. Adult *Lottia* are relatively easy to identify because of their large size (5 to 10 centimeters), oval shape with low rounded profile, and color patterns of brown, white, and black on the often eroded shell. Accessory gills on the mantle increase surface area for aerial respiration during low tide periods. Owl limpet habitats extend from the barnacle and *Endocladia* zones down to the mussel beds. They maintain feeding territories on relatively smooth rock surfaces which they keep free (by rasping and bulldozing) of most macroalgae and invertebrates (Stimpson 1970; Wright 1982). By removing most competitors they promote the growth of algal films upon which they systematically graze. These "clearings" vary in appearance with *Lottia* size and structural features of the substrate, creating a patchwork of differing microhabitats. *Lottia* tend to occupy one or more characteristic "home scars" within their territories. The limpets also may tuck into crevices and under mussels for protection from heat, desiccation, and high surf.

Lottia grow slowly, taking up to 10 to 15 years to reach maximum size (Morris et al. 1980). As an ecological dominant, any change in *Lottia* populations greatly affects abundances of other species. The limpets and their feeding territories are vulnerable to oiling, but oil impacts are unclear. For example, they were not obviously affected by the 1971 San Francisco oil spill (Chan 1973). Due to their slow growth, recovery from any major disturbance likely would be lengthy. Larger owl limpets are collected for food, tasting much like abalone (Murray 1998). Since the largest individuals are nearly always females (*Lottia* are protandrous hermaphrodites) (Wright and Lindberg 1982), collecting may impair reproductive capabilities within owl limpet populations.

<u>Mussels, Clams, and Scallops</u>

Mussels, clams, and scallops are mollusks of the Class Bivalvia. All bivalves have two hinged shells enclosing the rest of the animal. Bivalves feed by filtering particulate matter from sea water through their gills. They reside in or on the substrate as adults. Many species of bivalves occur in the Channel Islands area, with a sport fishery (for food or bait) being supported by the four species of particular interest described below plus others including purple clams (*Nuttallia nuttallii*), Washington clams (*Saxidomus nuttallii*), jacknife clams (*Tagelus californianus*), gapers (*Tresus nuttallii*), spiny cockles (*Trachycardium quadragenarium*), abalone jingles (*Pododesmus sepio*), oysters, San Diego scallops (*Pecten diegensis*), and speckled scallops (*Argopecten aequisulcatus*) (Thompson et al. 1993).

<u>California Mussel</u> (*Mytilus californianus*).

California mussels are abundant at middle to low levels of exposed rocky shores along the entire Pacific Coast. These 10- to 20-centimeter black/blue/gray mussels firmly attach to rocks or other mussels by tough byssal threads, forming dense patches or beds. The literature on *Mytilus californianus* is extensive, including key ecological studies on the effects of predation, grazing, and disturbance on succession and community structure (see for discussion Kinnetics,1992; Morris et al. 1980; Ricketts et al. 1985). The bay mussel, *M. galloprovincialis* (formerly mis-identified as *M. edulis*), can co-occur with *M. californianus*, but is most common in sheltered habitats.

Thick (20 centimeters or more) beds of California mussels trap water, sediment, and detritus that provide food and shelter for a large diversity of plants and animals, including cryptic forms inhabiting spaces between mussels as well as biota attached to mussel shells (Kanter 1980; MacGinitie and MacGinitie 1968; Paine 1966; Suchanek 1979). For example, MacGinitie and MacGinitie (1968) counted 625 mussels and 4,096 other invertebrates in a single 25 square centimeter clump, and Kanter (1980) identified 610 species of animals and 141 species of algae from mussel beds at the Channel Islands. Kinnetics (1992) documented locational differences in the composition and abundance of mussel bed species. Northern sites had densely packed, multi-layered beds, but the more open southern sites had higher species diversity. Mussels feed on suspended detritus and plankton. Young mussels settle preferentially into existing beds at irregular intervals, grow at variable rates depending on environmental conditions, and eventually reach ages of 8 years or more (Morris et al. 1980, Ricketts et al. 1985). Desiccation likely limits the upper extent of mussel beds, storms tear out various-sized mussel patches, and sea stars prey especially on lower zone mussels. Mussels are popularly harvested by sport collectors for food and bait. *Mytilus* are adversely affected by oil spills (Chan 1973; Foster et al. 1971). Recovery from disturbance varies from fairly rapid (if clearings are small and surrounded by mussels that can move in) to periods greater than 10 years (if clearings are large and recruitment is necessary for recolonization) (Kinnetics 1992; Vesco and Gillard 1980).

<u>Pismo clam</u> (*Tivela stultorum*).

Pismo clams inhabit the intertidal zone to subtidal depths (to 25 meters, but mostly less than 7 meters) from Monterey to central Baja California. Adults are found along surf-swept sandy shores. Pismo clams are identified by light colored shell with fine concentric growth lines and short externally-visible siphons. Adult Pismo clams are buried in the substrate and are relatively sedentary. This species may live up to 50 years (Leet et al. 1992). Pismo clams have supported a commercial and sport fishery in California since at least 1916. Natural predators include sea stars, snails, fishes, birds, and sea otters. Natural populations of Pismo clams on the mainland have been studied by the Department since 1923. Pismo clams occur at two specific locations at the Channel Islands (at Santa Cruz and Santa Rosa Islands) (Dugan et al. 1993; Engle et al. 1998).

<u>Geoduck</u> (*Panopea abrupta*).

Geoducks inhabit low intertidal levels to subtidal depths (to 100 meters) from Alaska to central Baja California. Adults are found in the sandy mud of protected bays or in deep water soft substrates. Geoducks are identified by whitish shells with irregular concentric growth lines and a huge, externally visible siphon (to 1 meter long). Adult geoducks are buried in the substrate and are relatively sedentary. This species has an extremely long life span (up to 146 years) (O'Clair and O'Clair 1998). Geoducks support a modest sport fishery in California, with divers or individuals on the beach digging up the clams. Their great depth in the sediment requires the use of high-pressure water jets for harvest which seriously disturbs the substrate. Some have expressed interest in developing such a fishery in southern California, but there is also concern about quickly overharvesting such long-lived animals. Natural predators of the geoduck are not known (Morris et al. 1980; O'Clair and O'Clair 1998). Populations of the geoduck are found around all four of the northern Channel Islands and along the coast south of Point Conception (Engle et al. 1998).

<u>Rock scallop</u> (*Crassedoma giganteum* [= *Hinnites giganteus*]).

Rock scallops inhabit low intertidal levels to subtidal depths (to 50 meters) from British Columbia (Canada) to central Baja California. In the Channel Islands, adults are found primarily on high-relief rocky reefs, pinnacles, and walls with moderate to high water motion. Rock scallops are identified by yellow-orange shell, orange flesh, blue eyes on tentacles at edge of mantle, and lack of a visible external siphon. The shell is frequently covered with fouling organisms. Adult rock scallops are attached to the substrate; post-larval juveniles (larger than 45 mm) can swim limited distances. This species may live up to 25 years (Leet et al. 1992). Rock scallops support a popular sport fishery for their tasty adductor muscle. It is difficult to assess the total fishery harvest of rock scallops, but nearly 1,000 were reported taken each year between 1978 and 1987 by divers aboard CPFVs, mostly at the Channel Islands (Leet et al. 2001). The sport fishery appears to have depleted some local populations. Known natural predators include sea stars although there are likely others. Populations of the rock scallop have not been well studied (Leet et al. 1992; Morris et al. 1980).

Market squid (*Loligo opalescens*).

The California market squid occurs off southern Alaska to central Baja California. They inhabit pelagic coastal waters, congregating to spawn in semi-protected bays, usually over a sand bottom with rocky outcroppings. Spawning in the Channel Islands often occurs from October through May. The average age of squid from fishery samples is approximately 185 days old (Leet et al. 2001). Eggs are deposited on the bottom in clusters, with juveniles emerging within approximately one month. Adults die after spawning. The diet of squid consists of small pelagic crustaceans, fishes, benthic worms, and their own young. Market squid have been harvested in California since 1863. The California fishery shifted its emphasis to the region in1961, where it is currently centered. The fishery has been marked by large-scale fluctuations in landings, with no apparent overall trend. Squid landings decrease greatly during strong el Niño events. Squid are harvested using strong lights over the water to attract schools of squid in relatively shallow spawning areas. Since 1984 squid landings have increased steadily to over 200 million pounds in 1999 with severe declines in 1992 and 1998 during strong el Niño events (Leet et al. 2001). The present status or structure of populations in the region is unclear and is presently being evaluated by the Department. However, historical evidence from research surveys and recent landing data, indicate that the biomass is large (Leet et al. 2001)

Squid are important prey for numerous fishes, birds, and marine mammals and their eggs are eaten by benthic echinoderms (Morris et al. 1980, Leet et al. 1992). The market squid is one of the principal items of the diet of Dall's porpoise and Risso's dolphins, pilot whales, sea lions, and elephant seals (Bonnell and Dailey 1993). Overall, squid are an important part of many food webs in the SCB (Leet et al.1992).

Sea Urchins

Sea urchins are benthic grazers relying on their outer covering of spines and tube feet for locomotion and protection. Five principal species occur within the Channel Islands: red, purple, white, coronado, and pink. The nocturnal, invertebrate-grazing coronado urchin (*Centrostephanus coronatus*) is a tropical species that reaches its northern limit at the Channel Islands. The pink urchin (*Allocentrotus fragilis*) occurs primarily on soft substrates at depths greater than 150 meters. Pink urchins are scavengers and often dominate the community in terms of biomass (Blake et al. 1996). The other urchins are major consumers of kelps and other algae. Red and purple urchins dwell in crevices and feed on drift kelp or emerge to consume attached plants (Morris et al. 1980; Leet et al. 1992). Urchin grazing may denude entire reefs of nearly all macroalgae, after which the urchins are capable of persisting in a near-starvation state, continuing to eat any newly settled plants (Ambrose et al. 1993; Carroll et al. 2000; Engle 1994; Harold and Reed 1985; Richards et al. 1997). These urchin barrens no longer support the highly diverse assemblages characteristic of balanced kelp-dominated ecosystems. Red, purple, and white urchins are susceptible to disturbance from major storms and a poorly understood disease that may dramatically reduce population sizes (Ebeling et al. 1985; Lafferty and Kushner 2000).

Red urchin (*Strongylocentrotus franciscanus*).

Red urchins inhabit low intertidal to subtidal depths (to 90 meters) from Alaska to central Baja California. They prefer open rocky shores. Red urchins are identified by their red, maroon, or black color and large size (10 centimeters commonly, to 20 centimeters) (Leet et al. 1992; Morris et al. 1980). When food is abundant, red urchins are relatively sedentary. However, when food is scarce, red urchin motility increases (to 1 meter per day) (Harrold and Reed 1985). Red urchin spines are refuges for a variety of small invertebrates (including juvenile red urchins) and fishes (Tegner and Dayton 1977). The diet of red urchins consists of a variety of red and brown algae, but Giant kelp is preferred. Red urchins compete with abalone for food and space, though their spine canopy provides shelter for smaller abalone. Red urchins may live 20 years or more (Morris et al. 1980). A significant commercial fishery for red urchin began during the 1970s in the region (Leet et al. 1992). Commercial hookah divers harvest red urchins using rakes at depths of up to 33 meters.

The relative abundance of red urchins has declined since the 1970's (e.g., Carroll et al. 2000). In southern California, the red sea urchin resource now produces about 10 million pounds annually, with harvestable stocks (defined as exceeding the minimum legal size and containing marketable gonads) in decline since 1990 (Leet et al. 2001). Between 1985 and 1995, the percentage of legal-sized red sea urchins at survey sites in the northern Channel Islands declined from 15 percent to 7.2 percent (Leet et al. 2001). Although fishing has significantly reduced density in many areas and catch-per-unit of effort has decreased, localized juvenile recruitment has, thus far, somewhat mitigated fishing pressure (Leet et al. 2001). Consistent recruitment has been noted on artificial settlement substrates and along subtidal transects over the last decade at monitoring stations along the southern California mainland coast and the northern Channel Islands (Leet et al. 2001). This may be partly due to ocean current patterns in the Southern California Bight, where water retention may increase the chances for larvae to encounter habitat suitable for settlement. Continued recruitment at present levels, however, is not guaranteed; in fact, intensive sea urchin harvesting in northern California and Baja California could result in a decrease in sea urchin larvae in southern California in the future. Other sources of mortality include predation by sea stars, fishes, lobsters, and sea otters (Leet et al. 1992; Tegner and Dayton 1981; Tegner and Levin 1983; Rogers-Bennett 1998).

Purple urchin (*Strongylocentrotus purpuratus*).

Purple urchins inhabit low intertidal to subtidal depths (to 160 meters) from southern British Columbia (Canada) to central Baja California. They prefer rocky habitats with moderate to strong wave action, where they normally inhabit crevices or depressions that they create. Purple urchins are identified by their purple color and relatively small size (to 8 cm). The diet of purple urchins consists of a variety of red and brown algae, but giant kelp is preferred. They are relatively sedentary when food is abundant, with motility increasing as food availability decreases (to 1 meter per day) (Harrold and Reed 1985). This species may live at least 30 years (Morris et al. 1980).

Coincident with the decline of competing red urchins, purple urchins populations have increased tremendously at many island sites, creating vast areas denuded of macroalgae (Harold and Reed 1985; Ambrose et al. 1993; Engle 1994; Richards et al. 1997; Carroll et al. 2000, Lafferty and Kushner 2000). A small fishery has existed sporadically for this species which peaked in 1992 at 400,000 pounds and then declined to less than 50,000 pounds in 1999 (Leet et al. 2001). A limited amount of this harvest has come from the Channel Islands.

White urchin (*Lytechinus anamesus*).

White urchins inhabit subtidal depths (2 to 300 meters) from the Channel Islands to central Baja California. They prefer soft substrates where they often occur in high densities. They can be one of the most dominant megafaunal species on deep-water mainland shelves (Thompson et al. 1993). They also periodically invade some shallow-water sand and rock habitats (Ambrose et al. 1993; Engle 1994; Richards et al. 1997; Carroll et al. 2000). White urchins are identified by their whitish color, small size (to 4 cm), and fragile test. White urchins are extremely effective grazers, capable of consuming kelp and other algae when density is high (Morris et al. 1980; Ambrose et al. 1993; Engle 1994; Richards et al. 1997; Carroll et al. 2000). In the Channel Islands, feeding fronts of white urchins apparently have eliminated eelgrass beds on the north side of Anacapa Island (Engle 1994). White urchins may also consume invertebrates, including other urchins (Coyer et al. 1987). There is no fishery for these small urchins. Predators of white urchins include sea stars and fishes (Schroeter et al. 1983).

Sea Cucumbers

Sea cucumbers are benthic animals with a variety of feeding strategies, from planktivory to bottom feeding (Morris et al. 1980). At least 12 species are known to occur in the Channel Islands though two (the warty and California sea cucumbers) are of particular interest as they support an expanding commercial fishery which began in 1978 and peaked in 1998 at nearly 900,00 pounds (Leet et al. 2001). It is apparent that harvesting has significantly reduced some sea cucumber populations. Studies comparing marine reserves with fished areas in the channel islands show that populations in fished sites range from 50 to more than 80 percent lower than those in MPAs (Leet et al. 2001).

California sea cucumber (*Parastichopus californicus*).

California sea cucumbers inhabit low intertidal levels to subtidal depths (to 90 meters) from Alaska to central Baja California; however, they rarely occur at depths above 30 meters in the region. Here, they occur predominantly on deep-water, soft-bottom habitats. These colder-water sea cucumbers are identified by their red, brown, or yellow color, large stiff papillae, and large size (to 40 centimeters). Although relatively sedentary, they may move up to 4 meters per day (Lambert 1997). The diet of California sea cucumbers consist of detritus and small organisms, which they ingest with bottom sediments. No sport fishery for this species exists. A commercial fishery using trawl gear for California sea cucumbers started in California in 1978 and dominated total sea cucumber landings until 1996 (Leet et al. 2001). In 1982, the center of the fishery shifted to the project area where they are harvested from the Santa Barbara Channel by trawling. This species may live about 12 years. (Morris et al. 1980; Leet et al. 1992). Sources of mortality besides fishing include predation by sea stars, fishes, and crabs.

Warty sea cucumber (*Parastichopus parvimensis*).

Warty sea cucumbers inhabit low intertidal levels to subtidal depths (to 27 meters) from Monterey Bay to central Baja California. These warmer-water sea cucumbers are common on both soft substrates and rocky reefs. Warty sea cucumbers are identified by their light-brown color, dorsal papillae, and smaller size than the California sea cucumber (to 25 centimeters). Warty sea cucumbers are common in the Channel Islands, though natural populations are poorly studied (Gotshall and Laurent 1979; Morris et al. 1980). This slow-moving sea cucumber feeds on detritus and small organisms, which it ingests with bottom sediments. It may live about 12 years (Morris et al. 1980; Leet et al. 1992). No sport fishery for this species exists. A commercial fishery by hookah divers using rakes started in California in 1978 (Leet et al. 1992). Initially, total sea cucumber landings were dominated by the trawl caught California sea cucumber, but since 1997 the total landings have been consisted of over 80 percent of the diver caught warty sea cucumbers (Leet et al. 2001). Other sources of mortality include predation by sea stars, fishes, crabs, and sea otters, and a bacterial disease that may significantly reduce population sizes (Eckert et al. 2000; Engle 1994).

<u>Ochre Sea Star</u> (*Pisaster ochraceus*).

Ochre sea stars are found on middle and low tide levels of wave-swept rocky coasts from Alaska to Baja California, but they are much less common south of Point Conception. Their relatively large size (to 45 centimeters diameter), variety of colors (yellow, orange, purple, brown), and ability to withstand air exposure (at least 8 hours) attract considerable attention from visitors exploring the shore at low tide. The ochre sea star typically is associated with mussels, which constitute its chief food, but barnacles, limpets, snails, and chitons also may be taken (Morris et al. 1980).

Predator-prey interactions involving ochre sea stars have been intensely studied, especially the role of *P. ochraceus* in determining the lower limit of northern mussel beds (Dayton 1971; Paine 1966, 1974). Like black abalone, ochre sea stars are relatively slow-growing, long-lived, and apparently variable in recruitment success. Tolerant of high surf, they use their numerous tube feet to remain firmly in place, often in cracks and crevices. They have few predators, except for the occasional sea gull or sea otter and curious tidepool visitors. However, in southern California, *P. ochraceus* populations have been decimated by a widespread wasting disease caused by a warm-water bacterium of the genus Vibrio (Eckert et al. 2000). Sensitivity to oil spills is not well known; Chan (1973) saw no obvious effects from a San Francisco oil spill. Due to their slow growth and low reproductive success recovery time from any major population loss likely would be very long.

4.3.3.4 Fishes

About 481 species of fish inhabit the SCB (Cross and Allen 1993). The great diversity of species in the area occurs for several reasons: (1) the ranges of many temperate and tropical species extend into and terminate in the SCB, (2) the area has complex bottom topography and a complex physical oceanographic regime that includes several water masses and a changeable marine climate (Cross and Allen 1993; Horn and Allen 1978), and (3) the islands and nearshore areas provide a diversity of habitats that include soft bottom, rock reefs, extensive kelp beds, and estuaries, bays, and lagoons.

The fish species found around the Channel Islands generally are representative of fish assemblages that occur along the southern California coast, with the addition of some central California species (Hubbs 1974). Eschemeyer et al. (1983) list 406 fish species whose ranges include the project area.

Table 4-2 shows some of the common fish species found in the project area.

Common Name	Scientific Name	Common Name	Scientific Name
Albacore	*Thunnus alalunga*	Rock Wrasse	*Halichoeres semicinctus*
Anchovy, Northern	*Engraulis mordax*	Rockfish, Gopher	*Sebastes carnatus*
Barracuda, Pacific	*Sphyraena argentea*	Rockfish, Yellowtail	*Sebastes flavidus*
Bass, Barred Sand	*Paralabrax nebulifer*	Rockfish, Black	*Sebastes melanops*
Bass, Giant Sea	Stereolepis gigas	Rockfish, Black and Yellow	*Sebastes chrysomelas*
Bass, Kelp	*Paralabrax clathratus*	Rockfish, Blue	*Sebastes mystinus*
Bass, Spotted Sand	*Paralabrax maculatofasciatus*	Rockfish, Bocaccio	*Sebastes paucispinis*
Bat Ray	*Myliobatis californica*	Rockfish, Brown	*Sebastes auriculatus*
Blacksmith	*Chromis punctipinnis*	Rockfish, Calico	*Sebastes dalli*
Bonito, Pacific	*Sarda chiliensis*	Rockfish, Calico	*Sebastes dalli*
Brown Smoothhound	*Mustelus henlei*	Rockfish, Canary	*Sebastes pinniger*
Butterfish, Pacific	*Peprilus simillimus*	Rockfish, China	*Sebastes nebulosus*
Ca. Scorpionfish (Sculpin)	*Scorpaena guttata*	Rockfish, Copper	*Sebastes caurinus*
Cabezon	*Scorpaenichthysm marmuratus*	Rockfish, Vermillion	*Sebastes miniatus*
California Sheephead	*Semicossyphus pulcher*	Rockfish, Grass	*Sebastes rastrelliger*
California Moray	*Gymnothorax nordax*	Rockfish, Halfbanded	*Sebastes semicinctus*
California Scorpionfish	*Scorpaena guttata*	Rockfish, Kelp	*Sebastes atrovirens*
California Flyingfish	*Cypelurus californicus*	Rockfish, Olive	*Sebastes serranoides*
California Halibut	*Paralichthys californicus*	Rockfish, Rosy	*Sebastes rosaceus*
Croaker, White	*Genyonemus lineatus*	Rockfish, Stripetail	*Sebastes saxicola*
Croaker, Black	*Cheilotrema saturnum*	Rockfish, Tree	*Sebastes serriceps*
Croaker, Yellowfin	*Umbrina roncador*	Rockfish, Yelloweye	*Sebastes rubervimus*
Eel, Monkeyface	*Cebidichthys violaceus*	Rockfish,Tiger	*Sebastes nigrocinctus*
Garibaldi	*Hypsypops rubicundus*	Ronquil, Stripedfin	*Rathbunella hypoplecta*
Goby, Bluebanded	*Lythrypnus dalli*	Salmon, King	*Oncorhynchus Tshawytscha*
Goby, Blackeye	*Coryphopterus nicholsi*	Sanddab, Pacific	*Citharicthys sordidus*
Goby, Zebra	*Lythryphus zebra*	Sanddab, Speckled	*Citharicthys stigmaeus*
Greenling, Kelp	*Hexagrammos decagrammus*	Sarcastic Fringehead	*Neoclinux blanchardi*
Greenling, Painted	*Oxylebius pictus*	Sardine, Pacific	*Sardinops sagax*
Greenling, Rock	*Hexagrammos lagocephalus*	Sargo	*Anisotremus davidsoni*
Grunion	*Leuresthes tenuis*	Saury, Pacific	*Coloabis saira*
Gunnel, Kelp	*Ulvicola sanctaerosae*	Sculpin, Snubnose	*Orthonopias Triacis*
Hake, Pacific	*Merluccius Productus*	Sculpin, Scalyhead	*Artedius harringtoni*
Half Moon	*Medialuna californiensis*	Sculpin, Wooly	*Clinocotius analis*
Horn Shark	*Heterodontus francisci*	Seaperch, Sharpnose	*Phanerodon atripes*
Jacksmelt	*Atherinops californiensis*	Seaperch, Striped	*Embiotoca lateralis*
Kelpfish, Island	*Alloclinus holderi*	Seaperch, Rubberlip	*Rhacochilus toxotes*
Kelpfish, Crevice	*Gibbonsia montereyensis*	Seaperch, Rainbow	*Hypsurus caryi*
Kelpfish, Giant	*Heterostichus rostratus*	Señorita	*Oxyjulis californuca*
Kelpfish, Spotted	*Gibbonsia elegans*	Shark, Blue	*Prionace glauca*
Lingcod	*Ophiodon elongatus*	Shark, Mako	*Isurus oxyrnchus*
Mackerel, Pacific	*Scomber japonicus*	Shark, Soupfin	*Galeorhinus galeus*
Mackerel, Jack	*Trachurus symmetricus*	Shark, Spiny Dogfish	*Squalus acanthias*
Northern Ronquil	*Ronquilus Jordani*	Shark, Swell	*Cephaloscyllium ventriosum*
Ocean Sunfish	*Mola mola*	Shark, Thresher	*Alopias vulpinus*
Opah	*Lampris guttatus*	Shark, White	*Carcharodon carcharias*
Opaleye	*Girella nigricans*	Shark, Leopard	*Triakis semifasciata*
Orangethroat Pikeblenny	*Chaenopsis alepidota*	Siversides	*Atherinidae*
Queenfish	*Seriphus politus*	Sole, Sand	*Psettichthys melanostictus*
Reef Perch	*Micrometrus aurora*	Sole, English	*Pleuronectes vetulus*

Common Name	Scientific Name
Sole, Rock	*Pleuronectes bilineatus*
Spotted Cusk-eel	*Chilara taylori*
Spotted Turbot	*Pleuronichthys ritteri*
Surfperch, Barred	*Amphistichus argenteus*
Surfperch, Black	*Embiotoca jacksoni*
Surfperch, Island	*Cymatogaster gracilis*
Surfperch, Kelp	*Brachyistius frenatus*
Surfperch, Pile	*Damalichthys vacca*
Surfperch, Pink	*Zalembius rosaceus*
Surfperch, Shiner	*Cymatogaster aggregata*
Surfperch, Spotfin	*Hyperprosopon anale*
Surfperch, Calico	*Amphistichus koelzi*
Surfperch, White	*Phanerodon furcatus*
Surfperch, Walleye	*Hyperprosopon argenteum*
Swordfish	*Xiphias gladius*
Thornback	*Platyrhinoidis triseriata*
Topsmelt	*Atherinops affinis*
Tube Snout	*Aulorhynchus flavidus*
Turbot, Hornyhead	*Pleuronichthys verticallis*
Turbot, Curlfin	*Pleuronichthys decurrens*
Turbot, C-O	*Pleuronichthys coenosus*
White Sea Bass	*Atractoscion nobilis*
Whitespotted Greenling	*Hexagrammos stelleri*
Yellowfin Fringehead	*Neoclinus stephensae*
Zebra Perch	*Hermosilla azurea*

During their life cycles and over the period of a day, fish may occupy more than one habitat. Some bays and estuaries serve as nursery areas for juveniles of some species. At night, some benthic and midwater species rise to the surface and other species that dwell in kelp forest may become pelagic (i.e., mid-water) or move out over soft or rock substrates (i.e., ocean bottom habitats). Marine fish typically migrate for feeding and reproduction. Dover sole (*Microstomus pacificus*) migrate into deep water during winter for reproduction and migrate into shallow water in summer for feeding. Scorpion fish (*Scorpaena guttata*) migrate off shore and spawn within previously spawned areas from May through August. In the fall, Pacific hake migrate from their summer feeding grounds in the California Current off the Pacific Northwest to their winter spawning grounds off southern California and Baja California (Cross and Allen 1993). Other marine fishes migrate over a wide range to seek favorable areas and avoid unfavorable conditions, and their abundance in the Sanctuary is affected by large-scale environmental fluctuations such as the El Niño cycle (Venrick 1983). Commercial and recreational landings of subtropical species such as yellowtail, California barracuda (*Sphyraena argentea*), skipjack tuna (*Euthynnus pelamis*) and yellowfin tuna (*Thunnus albacares*) increase dramatically during warm years when large numbers migrate into the SCB from their distribution centers off Mexico.

Nearshore Fish

Abundance of fish assemblages is greater at the northern Channel Islands than at nearby coastal regions of the southern California mainland. One reason for this is the high quality of nearshore habitats associated with the northern Channel Islands.

Fish abundance on nearshore reefs is related to the presence or absence of kelp and substrate topography. The abundance of water column fish such as kelp surfperch (*Brachyistius frenatus*), kelp bass (*Paralabrax clathratus*), giant kelpfish (*Heterostichus rostratus*), and kelp rockfish (*Sebastes atrovirens*) are directly correlated with kelp density. Kelp beds are not important spawning areas for fish, but they are important nursery areas for juvenile fishes. Juvenile and adult kelp bass occur in both kelp beds and on rocky reefs devoid of kelp (Cross and Allen 1993).

Hard substrates are the least abundant, but among the most important of fish habitats in the SCB (Cross and Allen 1993). About 30 percent of the species and 40 percent of fish families in the SCB occupy this habitat (Cross and Allen 1993). The composition of reef fish assemblages is influenced by the physical characteristics of the reef (Ebeling et al. 1980a, b; Larson and DeMartini 1984), and by water temperatures (Stephens and Zerba 1981; Stephens et al. 1984). Shelter-seeking species such as blacksmith (*Chromis punctipinnis*), garibaldi (*Hypsopops rubicundus*), grass rockfish, (*Sebastes rastrelliger*) brown rockfish (Sebastes *auriculatus*) and gopher rockfish (*Sebastes carnatus*) are abundant on high-relief reefs, but they are rare or absent on low-relief reefs (Larson and DeMartini 1984).

In the northern SCB, the kelp canopy is dominated by plankton-eating and kelp-browsing species such as blacksmith, kelp surfperch, blue rockfish (*Sebastes mystinus*) juvenile olive rockfish and senorita (Ebeling et al. 1980 a, b). The canopy assemblage is made up of large populations of just a few species of fish (Cross and Allen 1993). The most common, conspicuous fish in the canopies of kelp beds on high-relief bench reefs off Santa Barbara and Santa Cruz Island are blue rockfish (41 percent) and kelp surfperch (35 percent) respectively (Ebeling et al. 1980a). Blacksmith represent 36 and 33 percent of the assemblages at these locations, respectively. Fish that ambush their prey or graze, such as pile surfperch, (*Damalicthys vacca*) black surfperch, garibaldi, California sheephead (*Semicossphylus pulcher*) gopher rockfish (Sebastes carnautus) and black-and-yellow rockfish (*Sebastes chrysomelas*) occupy the reef itself. The kelp bed bottom assemblages consist of smaller populations of a relatively larger number of fish species. The most common fishes near the bottom of the Santa Barbara kelp bed are black surfperch (28 percent); at Santa Cruz Island, kelp bass (14 percent).

The rocky intertidal is a turbulent and dynamic environment where fish must cope with waves, surge and physiological stresses imposed by the ebb and flow of tides. Only six species of fish reside in the rocky intertidal including wooly sculpin (*Clinocotus analis*), reef finspot (*Paraclinus integripinnis*), rockpool blenny (*Hypsoblennius gilberti*), spotted kelpfish (*Gibbonsi elegans*), and California clingfish (*Gobiesox rhesssodon*) (Cross and Allen 1993).

<u>Black Rockfish</u> (*Sebastes melanops*)

Black rockfish range from Amchitka Island, Alaska to Santa Monica Bay in southern California, but are uncommon south of Santa Cruz (Leet et al. 2001). They are found mixing with warmer water species in the project area. They frequently occur in loose schools ten to twenty feet above shallow (to 120 feet) rocky reefs, but may also be observed as individuals resting on rocky bottom, or schooling in midwater over deeper (to 240 feet) reefs (Leet et al. 2001). Black rockfish have a relatively fast growth rate. First year growth is usually 3.5 to 4.0 inches. At six years, or about 14 inches, half of all males are sexually mature. At seven to eight years, or about 16 inches, half of all females are sexually mature (Leet et al. 2001).

Commercial Landings from port areas south of San Francisco have never comprised more than 10 percent of total landings in the market category. In the San Francisco port area, black rockfish landings increased fifteen-fold from 1989 to 1992. The majority of black rockfish in commercial fisheries are landed dead but a small portion are now landed live in the recently expanded live fish fishery, primarily from Morro Bay north to Fort Bragg. They are also taken incidentally in the commercial salmon troll fishery (Leet et al. 2001).

South of the Eureka area, black rockfish gradually decrease in importance in the recreational catch and are infrequently observed south of Santa Cruz. They are often among the top 10 species observed annually in Commercial Passenger Fishing Vessel (CPFV) catches from Fort Bragg south to the San Francisco/Princeton area (Leet et al. 2001). Black rockfish also are important to divers. In a 1972 survey in northern and central California, black rockfish comprised approximately eight percent of all fish taken by divers, and were primarily taken in northern California (Leet et al. 2001).

Though mean size of individual black rockfish has decreased in both the recreational and commercial catch, this has been coupled with increases in catch per unit effort. The two factors together indicate sustained recruitment of young fish into the population (Leet et al. 2001). Adult fish must still be present in the population to provide for this continued recruitment (Leet et al. 2001).

<u>Blue Rockfish</u> (*Sebastes mystinus*)

Blue rockfish range from the Bering Sea to Punta Baja, Baja California, and from surface waters to a maximum depth of 300 feet (Leet et al. 2001). They are less common south of the northern Channel Islands and north of Eureka. In central and southern California, larger blue rockfish are now common only in areas distant from fishing ports or in larger kelp beds which are practical to fish only from the edges. Rockfishes in general are considered to be slow-growing fishes. However, blue rockfish are among the faster growing rockfishes. First year growth may vary from 3.0 to 4.5 inches (central California average about 4.25 inches) (Leet et al. 2001). Age at first spawning is protracted for both sexes. Only about 10 percent spawn for the first time at three years of age. At five years, or about 10 to 10.5 inches, half of all males are sexually mature. At six years, or about 11 inches, half of all females have spawned (Leet et al. 2001).

Although only a small portion of blue rockfish landings is from the commercial fishery, those landings have increased in the past decade. During the 1987-1989 period, landings in the blue rockfish market category (which may include other morphologically similar rockfishes) averaged 25,670 pounds; in 1998 landings were approximately 92,000 pounds (Leet et al. 2001). Blue rockfish have become a minor component of the live fish fishery, which developed during the 1990s in California.

The blue rockfish is one of the most important recreational species in California. It is usually the most frequently caught rockfish north of Point Conception for anglers fishing from skiffs and CPFVs (Leet et al. 2001). It is also an important species for skin and scuba divers using spears, and is occasionally caught by shore anglers fishing in rocky subtidal areas. In a 1981-1986 survey of sport fish taken between the southern boundary of San Luis Obispo County and Oregon, an estimated 800,000 blue rockfish were harvested annually, more than any other species. This represents a doubling of the estimated annual harvest from a similar survey conducted in 1957-1961 (Leet et al. 2001).

There is evidence of a decline in blue rockfish stocks off southern California since the 1970s (Leet et al. 2001). There is a well-documented difference in the population structure between northern and central California stocks. Northern stocks are generally characterized by a wider size range of adults, a higher proportion of adults greater than 15 inches and a correspondingly greater mean length, less variability in annual recruitment, and most likely a higher growth rate (Leet et al. 2001). These attributes are likely a result of a combination of greater fishing pressure and a greater influence of anomalous oceanic conditions such as El Niño events in central California.

<u>Brown Rockfish</u> (*Sebastes auriculatus*),

Brown rockfish are found along the Pacific Coast of North America from the northern Gulf of Alaska to central Baja California (Leet et al. 2001). They live in shallow subtidal waters and bays, and have been found at depths of just over 400 feet, although they most commonly reside above 175 feet (Leet et al. 2001). Brown rockfish are typically found associated with sand-rock interfaces and rocky bottoms of artificial and natural reefs. Recent studies found maturity as early as three years, and 100 percent maturity at six years, or roughly 12.2 inches total length (TL) (Leet et al. 2001). Half of the population was mature at 3.9 and 4.2 years of age, measuring 9.8 and 10.4 inches TL in males and females, respectively (Leet et al. 2001).

The number of vessels landing brown rockfish peaked in the early 1990s, when over 250 hook-and-line vessels made an average of over 1,300 landings per year statewide, usually ranging from 60 to just over 100 pounds per landing (Leet et al. 2001). Total landings of brown rockfish peaked in 1991, decreased through the mid-1990s, and increased again during the late 1990s coincident with an increasingly active nearshore premium and live fish fishery (Leet et al. 2001). Though landings have fluctuated over the last two decades, the value of the catch has continued to increase, particularly during the last decade, as rockfish quotas have been reduced and demand has continued to remain high (Leet et al. 2001).

In a sport fish survey conducted from 1980 through 1986, brown rockfish were among the top five species of rockfish caught and composed up to 6.6 percent of the estimated sport catch (Leet et al. 2001). Although catches south of Point Conception are lower, brown rockfish have comprised up to one percent of rock- fish take and have remained among the top 15 species of rockfish caught during the last 20 years.

Although nearly half of the fish landed statewide are adults that can replenish the population, there are now few large adults above the length of the median-sized fish recorded in the 1958 through 1961 survey (Leet et al. 2001). The brown rockfish has been identified as a species vulnerable to severe localized depletions in other geographic areas; in Washington state, the Puget Sound stock of brown rockfish was recommended for listing as a threatened species in 1999 (Leet et al. 2001).

<u>Calico Rockfish</u> (*Sebastes dalli*)

Calico rockfish range from Sebastian Viscaino Bay, Baja California to San Francisco within a depth range of 60 to 840 feet (Leet et al. 2001). Juvenile calico rockfish are found in areas of soft sand-silt sediment, and on artificial reefs. Adults inhabit rocky shelf areas where there is a mud-rock or sand-mud interface with fine sediments. They are usually associated with structures that provide vertical relief and sheltered habitat, including artificial reefs (Leet et al. 2001).

Calico rockfish comprise a very minor portion of the state's commercial catch. Their small size and scattered distribution probably preclude them from being targeted (Leet et al. 2001). Calico rockfish, however, may be one of several small rockfish species, including squarespot, honeycomb, halfbanded and starry rockfishes, that are caught and subsequently discarded at sea as an unmarketable bycatch in nearshore hook-and-line, trap, or trawl fisheries. The quantity of calico rockfish bycatch in these fisheries is currently undetermined (Leet et al. 2001).

Calico rockfish are taken in the southern and central California sportfisheries for nearshore rockfishes (Leet et al. 2001). During the 1980s, the estimated annual calico rockfish sport catch averaged 8,900fish with a high of 21,000fish taken in 1985. A more recent estimate of annual California sport catches of calico rockfish averaged 5,700fish per year between 1993 and 1999, with a high of 8,000 calico rockfish caught in 1995 and in 1998 (Leet et al. 2001).

There are currently no estimates of abundance for calico rockfish in California (Leet et al. 2001). There were more calico rockfish landed annually by sport anglers in the 1980s than in the 1990s, which may have been a reflection of the abundance of that species during two strong El Niño events that occurred in the 1980s (Leet et al. 2001). Whether the reduced calico rockfish catch during the 1990s was a result of changing oceanic conditions or was due to actual depletion of calico rockfish stocks by sport and commercial fisheries is not known.

<u>Copper Rockfish</u> (*Sebastes caurinus*)

The copper rockfish is broadly distributed geographically, known from the Gulf of Alaska to off central Baja California, Mexico (Leet et al. 2001). It also has a broad bathymetric distribution, known to occur from the shallow subtidal to 600 feet. Young-of-the-year copper rockfish are pelagic and recruit into the nearshore environment at about 0.8 to 1.0 inch during April and May off central California (Leet et al. 2001). The newly recruited copper rockfish initially associate with canopy-forming kelps such as *Macrocystis*, *Cystoseira*, and *Nereocystis*. After several months, and at about 1.6 inches, the juveniles settle to the bottom on rocky reef as well as sandy areas and are referred to as benthic juveniles (Leet et al. 2001).

Over the past 20 years, copper rockfish have become a less frequent component of the nearshore environment (Leet et al. 2001). Commercially, copper rockfish are landed in a number of market categories including copper rockfish as well as red, bolina, and gopher rockfish groups. It is sold as fillets by the market names rockfish or red rockfish and often whole as red rockcod; it is considered an excellent food fish. Copper rockfish is one of the species taken in the live-fish fishery. They have been an important component of the recreational catch in both skiff and commercial passenger fishing vessel fisheries, especially off central and northern California. Due to its relatively large size, known to reach 22.9 inches in length, copper rockfish has been considered one of the premium species in the recreational angler's catch and a prime target for the sport diver.

There has been no stock assessment of this species in California (Leet et al. 2001). However, there is compelling evidence that copper rockfish populations have severely declined in many areas and large individuals are noticeably less common than in past decades. Due to their solitary nature, high habitat specificity, and the size they can enter the fishery (as juveniles), the copper rockfish is a prime candidate for local depletion (Leet et al. 2001).

<u>Olive Rockfish</u> (*Sebastes serranoides*)

Olive rockfish occur from southern Oregon to Islas San Benitos (central Baja California) from barely subtidal waters to 570 feet (the latter based on a trawl specimen collected by the Southern California Coastal Water Research Project) (Leet et al. 2001). They are common from about Cape Mendocino to Santa Barbara and around the Northern Channel Islands from surface waters to about 396 feet (Leet et al. 2001). During the day, young fish aggregate in the water column, occasionally with blue and black rockfish. They spend the night near or on the bottom, sheltering under algae or among rocks. Young olives also are found under drifting kelp mats (Leet et al. 2001).

Olive rockfish (Sebastes serranoides) form a minor part of the commercial fishery in central and southern California, where they are primarily taken by hook-and-line (Leet et al. 2001). A relatively small number find their way into the live fish fishery. Historically, olive rockfish have been common in the recreational fishery as far north as Fort Bragg and were particularly important from central California to the northern Channel Islands (Leet et al. 2001). As late as the 1980s, olives were a very important recreational species throughout much of southern California. However, a combination of overfishing and poor juvenile survival brought about by changes in oceanographic conditions led to a steep decline (83 percent) in southern California party vessel catches between 1980 and 1996 (Leet et al. 2001). There has been no stock assessment of this species. However, there is clear evidence that olive rockfish have declined in abundance south of Pt. Conception (Leet et al. 2001).

<u>Quillback Rockfish</u> (*Sebastes maliger*)

Quillback rockfish are known from the Gulf of Alaska to Anacapa Passage in southern California, and are considered common between southeast Alaska and northern California (Leet et al. 2001). They are found from near the surface to a depth of 900 feet and can be common at depths of several hundred feet. Juveniles inhabit very nearshore bottom areas and are found over both low and high rocky substrate. They are sometimes found among sponges and algae that provide shelter (Leet et al. 2001). Adults are most often found in deeper water and are solitary reef-dwellers living in close association with the bottom. They are often seen perched on rocks or taking shelter in crevices and holes. Adults have also been noted to retreat to eelgrass beds at night (Leet et al. 2001).

Commercial landings of the quillback rockfish market category are significant only from the San Francisco area northward (Leet et al. 2001). However, historical landings are difficult to determine because of the low frequency of quillback rockfish and confused identification with other similar species. Statewide landings in this market category in 1999 comprised less than 0.3 percent of all rockfishes (Leet et al. 2001). Since 1992, this market category has not been used every year and when used, may have consisted of several different species (Leet et al. 2001).

Quillback rockfish (Sebastes maliger) are a minor component of the commercial passenger fishing vessel (CPFV) fishery and in general are only observed from the ports of Monterey northward (Leet et al. 2001). Only in the Eureka area does this species rank among the 10 most frequently observed benthic sport fishes caught by CPFV anglers (Leet et al. 2001).

While no stock assessment has been done for quillback rockfish in California, length-frequency data exist on their occurrence in the recreational fishery in northern and central California, as well as in the commercial fishery from the same region (Leet et al. 2001). Between the late 1980s and mid-1990s, quillback rockfish experienced increased take by the commercial fishery as the market demand for premium, live fish increased, yet no significant trend was noted in the average size of fish. Fishing pressure has relaxed somewhat in recent years because of restrictions placed on the fishery. Concern over sustainability of the commercial and recreational nearshore fishery has made this species of particular interest to managers (Leet et al. 2001).

Vermilion Rockfish (*Sebastes miniatus*)

Vermilion rockfish are found from the San Benito Islands, Baja California, to Prince William Sound, Alaska, and occur over rocky bottoms from the shallow subtidal to 1,400 feet (Leet et al. 2001). Large fish are more common at depths greater than 100 feet. Vermillion rockfish are extremely long-lived. A 20-inch individual weighing 5.4 pounds was aged, using surface aging, at 25 years (Leet et al. 2001). Lengths up to 30 inches have been reported. Vermilion rockfish have lengthy juvenile life stages. Fifty percent of the population is mature at eight years and these fish average 14 inches (Leet et al. 2001). The slow growth and long juvenile period make vermilion rockfish very susceptible to overfishing. Once large individuals are removed from a reef system they are replaced only by larval settlement.

Vermilion rockfish, though highly desirable because of their brilliant color and the flaky texture of their flesh when cooked, are only of moderate importance in California's commercial and sport fisheries (Leet et al. 2001). It is difficult to accurately determine what percent of the commercial catch is comprised of vermilion rockfish, because individuals in reported landings are often misidentified or combined with other red and orange-colored rockfishes in the market category of "rockfish, Group Red".
Vermilion rockfish comprised less than two percent of all landed fishes observed on commercial passenger fishing vessels (CPFV) from Fort Bragg to Monterey from 1992 through 1995 (Leet et al. 2001). During this same period, they constituted between six and eight percent of all landed fishes observed on CPFVs from Port San Luis and Morro Bay and averaged 14 inches in length (Leet et al. 2001). Along lightly fished areas of the central coast, fish of comparable size comprised eight percent of the total CPFV catch (Leet et al. 2001). There are no stock estimates for this species.

Cabezon (*Scorpaenichthys marmoratus*)

Cabezon populations range along the eastern Pacific coast from Point Abreojos, Baja California to Sitka, Alaska (Leet et al. 2001). They are found on hard bottoms in shallow water from intertidal pools to depths of 250 feet (Leet et al. 2001). Fish frequent subtidal habitats in or around rocky reef areas and in kelp beds (Leet et al. 2001). Average size of males in their fourth year is 17 inches. Some females begin to mature in their fourth year between 16 and 20 inches in length, and all females are sexually mature by the sixth year when they are 19 to 23 inches in length. These data, collected from 1950-1951, suggest a size of female 50 percent maturity greater than 16 inches (Leet et al. 2001).

The commercial catch of cabezon started increasing in 1992 with the expansion of marketing live fish to markets and restaurants in California's Asian communities (Leet et al. 2001). Most of the initial increase in landings was from the Morro Bay area, but by 1995, landings in most central and northern California ports had increased dramatically. Sampled catches from the Morro Bay area from 1995 to 1998 suggested a large proportion of landings were immature fish (Leet et al. 2001). Commercial landings continued to increase through 1998 with over 373,000 pounds reported, then declined slightly in 1999 but remained over 300,000 pounds. Live fish are taken primarily by trap and hook-and-line gear. About 90 percent of the catch is landed live (Leet et al. 2001).

As game fish, cabezon are prized by sport divers for edibility, size, and ease of capture. The recreational take aboard commercial passenger fishing vessels (CPFVs) does not comprise a large proportion of the catch, but those that are taken are usually of a good size, averaging around 3.5 pounds (Leet et al. 2001). In central California, cabezon generally account for less than one percent of observed annual CPFV catches (Leet et al. 2001). Recreational landings data are available from 1980 to 1999 for CPFV and private boat anglers as well as shore and pier anglers from the National Marine Fisheries Service Recreational Fisheries Information Network (RecFIN). RecFIN data from 1982 to 1999, for all four modes of recreational fishing showed a 40 percent decline in average annual landings between the 1982 through 1989 and 1993 through 1999 periods, from 122 to 74 tons. Data from RecFIN also suggest that cabezon are more common in catches north of Point Conception and more frequently caught by anglers fishing on private boats and from shore than on CPFVs.

Limited information is available on population biology or changes in biomass over time (Leet et al. 2001). Recent increases in commercial fishing pressure on cabezon have intensified efforts to learn more about their life history characteristics, population biology, and to assess stock size. Recreational landings have declined concurrent with the increase in commercial fishing efforts and reported commercial landings. As fishing effort increases, it is likely that populations living in heavily utilized areas will decline further (Leet et al. 2001).

California Halibut (*Paralichthys californicus*)

California halibut range from the Quillayute River, Washington to Almejas Bay, Baja California (Leet et al. 2001). Adult California halibut inhabit soft bottom habitats in coastal waters generally less than 300 feet deep, with greatest abundance at depths of less than 100 feet (Leet et al. 2001). California halibut may live to 30 years and reach 60 inches in length. The maximum-recorded weight is 72 pounds. Male halibut mature at one to three years and eight to twelve inches, whereas females mature at four to five years and 15 to 17 inches. Female halibut attain larger sizes at age than males and represent a greater fraction of the commercial landings (60 to 80 percent). Female halibut reach legal size (22 inches) at five to six years of age, about a year before males (Leet et al. 2001).

Historically, halibut have been commercially harvested by three principal gears: otter trawl, set gill and trammel net, and hook-and-line. The California halibut trawl fishery evolved late in the 19th century in the San Francisco Bay area. Today, trawling is permitted in Federal waters (three to 200 nautical miles offshore) and State waters, except in the designated “California halibut trawl grounds,” which encompass the area between Point Arguello and Point Mugu in waters greater than one nautical mile from shore.

A decade after the introduction of the trawl fishery to San Francisco Bay, set gill and trammel nets were fished statewide along the coast. Historically, set nets have been the gear of choice for commercial halibut fishermen because of the restrictions on bottom trawl gear in State waters. Today, gill and trammel net fishing is prohibited in Santa Monica Bay, shallow coastal waters north of Point Sal, and is subject to many other area, depth, and seasonal closures throughout the State. A Marine Resources Protection Zone (MRPZ) was established in 1990 extending three miles off the southern California mainland coast from Point Conception to the Mexican border and within one mile or 70 fathoms (whichever is less) around the Channel Islands. Gill and trammel nets have been prohibited in the MRPZ since January 1, 1994.

The highest recorded commercial landing of halibut was 4.7 million pounds in 1919, which was followed by an overall decline to a low of 950,000 pounds in 1932 (Leet et al. 2001). Since 1932, the average annual catch has been 910,000 pounds, with five notable peaks in landings: 1936 (1.58 million pounds), 1946 (2.46 million pounds), 1964 (1.28 million pounds), 1981 (1.26 million pounds), and 1997 (1.25 million pounds) (Leet et al. 2001). The decline in commercial halibut landings after 1919 has been attributed to increased fishing pressure during World War I and to overfishing (Leet et al. 2001). Fishing restraints during World War II may have allowed halibut stocks to increase, resulting in peak landings in the late 1940s, followed by low catches in the 1950s. Increased landings in the mid-1960s followed warm water (El Niño) years in the late 1950s. The lowest landings occurred in the early 1970s, with the lowest recorded catch in 1970 of 257,000 pounds (Leet et al. 2001). Landings increased during the late 1970s to a peak again in 1981 and 1997. Since 1980, landings of California halibut have remained relatively constant, averaging more than one million pounds annually (Leet et al. 2001).

Catches by commercial passenger fishing vessels (CPFV) displayed trends similar to the commercial landings from 1947 through 1974, with two peaks in 1948 (143,000 halibut) and 1964 (141,000 halibut) (Leet et al. 2001). Following the 1948 peak, annual landings plummeted below 11,000 fish by 1957. The expansion of the CPFV fleet and no size limit restriction for the take of California halibut can be attributed to the 13-fold decrease in landings between 1948 and 1958 (Leet et al. 2001). While the commercial catch increased in the late 1970s and steadied in the 1980s, the recreational catch remained low and variable with an average annual catch of 8,600 fish from 1971 to 1989. By 1995, CPFV landings surged to a 26-year high of 19,600 fish, declining to 14,200 fish in 1999 (Leet et al. 2001). To assist with the restoration of the California halibut resource through the protection of sub-adult fish, a regulation was adopted in 1971 that set a minimum size limit of 22 inches for sport-caught California halibut. Commercial landings increased slowly after this legislation, whereas recreational landings remained low and did not recover to former catch levels (Leet et al. 2001).

Abundance of larval California halibut in plankton surveys is correlated with commercial landings of halibut, suggesting that this species has a cycle of abundance approximately 20 years in length. However, the size of the halibut population may be limited by the amount of available nursery habitat, as juvenile halibut appear to be dependent on shallow water embayments as nursery areas. The overall decline in California halibut landings corresponds to a decline in shallow water habitats in southern California associated with dredging and filling of bays and wetlands. The total California biomass of the halibut resource obtained from virtual population analysis (VPA) estimates in the late 1980s was 5.7 to 13.2 million pounds, with annual recruitment of fish at age one estimated to be between 0.45 and 1.0 million fish (Leet et al. 2001). The number of juvenile halibut emigrating from southern California bays to the open coast (age one) estimated from beam trawl surveys ranged between 250,000 and 400,000 in the late 1980s (Leet et al. 2001). In the early 1990s, a swept-area trawl survey was conducted to better understand California halibut population dynamics. This fishery-independent survey produced a biomass and population estimate for halibut in southern and central California. The survey results indicated a halibut biomass of 6.9 million pounds for southern California and 2.3 million pounds for central California, while the population estimate was 3.9 million halibut for southern California, and 700,000 halibut for central California (Leet et al. 2001).

<u>Sanddabs</u> (*Citharichthys spp.*)

Four species of sanddabs are found in California waters; Pacific sanddab (*Citharichthys sordidus*), longfin sanddab (*C. xanthostigma*), speckled sanddab (*C. stigmaeus*), and gulf sanddab (*C. fragilis*) (Leet et al. 2001). Biogeographically, Pacific sanddab and speckled sanddab are temperate species whereas longfin sanddab and gulf sanddab are warm-temperate to tropical species. Pacific sanddab ranges from the Bering Sea to Cape San Lucas, Baja California Sur, Mexico; speckled sanddab from Point Montague Island, Alaska to Magdalena Bay, Baja California Sur, Mexico; longfin sanddab from Monterey Bay to Costa Rica; and gulf sanddab from off Ventura, California to Cape San Lucas, Baja California Sur, and the Gulf of California (Leet et al. 2001). Speckled sanddab occur from the surface to a depth of 1,200 feet and Pacific sanddab from 30 to 1,800 feet (Leet et al. 2001). Maximum depths of both species are suspect as the speckled sanddab seldom occurs deeper than 300 feet and Pacific sanddab seldom deeper than 600 feet (Leet et al. 2001). Longfin sanddab occurs at depths from seven to 660 feet, but usually less than 450 feet, and gulf sanddab from 59 to 1,140 feet (Leet et al. 2001). Most species are found on muddy to sandy mud bottoms but speckled sanddab occurs commonly on sandy bottoms.

Pacific sanddab is the largest species, reaching 16 inches, and up to two pounds (Leet et al. 2001). Most, however, are smaller than 10 inches and weigh, at most, 0.5 pound (Leet et al. 2001). The next largest species is longfin sanddab at 10 inches, followed by gulf sanddab at nine inches, and speckled sanddab at seven inches (Leet et al. 2001). Pacific sanddab live to a maximum of 10 years whereas speckled sanddab live to about 3.5 years (Leet et al. 2001). Pacific sanddabs mature at about three years, whereas the speckled sanddab matures at one year (Leet et al. 2001).

Although not as important to California fisheries as other flatfishes, sanddabs are nevertheless highly prized by the commercial industry and recreational anglers for their excellent edibility (Leet et al. 2001). Commercial sanddab landings and recreational catches consist predominantly of the two largest species, Pacific sanddab and longfin sanddab (Leet et al. 2001). Pacific sanddab is the most abundant and makes up the bulk of the landings in central and northern California waters, whereas Pacific sanddab and longfin sanddab are caught in southern California (Leet et al. 2001). Because of their smaller size, speckled and gulf sanddabs are not important to the fisheries.

Recorded sanddab landings were highest (2.6 million pounds) in 1917. In 1918, landings decreased to 1.8 million pounds, and from 1919 to 1921 they remained less than 0.8 million pounds. In 1922, annual landings increased, reaching approximately two million pounds in 1925. From 1930 to 1974, annual landings were below a million pounds. Since 1975, landings have fluctuated between 1.4 million pounds and 0.6 million pounds annually. During the last decade, landings have been above the historical annual average, except for 1983 and 1984, the period of a strong El Niño event. Landings rebounded in 1985 and have increased since then. Approximately 1.44 million pounds were landed in 1990, but landings crashed in 1992 (also an El Niño year) to 0.6 million pounds, and then rebounded to more than 2.0 million pounds in 1997 and 1999 (Leet et al. 2001).

Sanddabs are one of a few fish groups for which there is no catch limit. Sanddab catches from CPFVs were small during the 1990s, with reported catches reaching 2,200 fish in 1990 and dropping to about 100 fish in 1998 (a strong El Niño year) (Leet et al. 2001). About 70 percent of these were taken in southern California between Long Beach and Newport Beach. Sanddabs comprise an unknown, but probably large part of the unspecified flatfish catch, which has decreased from about 14,000 fish in 1990 to 4,000 fish in 1998 (Leet et al. 2001). As an El Niño event is more likely to have an immediate affect on the abundance of sanddab larvae than on harvestable adults, the immediate drop in sanddab catches during some El Niño years may be due in part to a shift in fishing effort to more desirable species.

Commercial landings indicate that sanddab populations are in good condition and currently are not being overharvested. The Pacific Fishery Management Council has not recommended a change in the minimal acceptable biological catch of incidentally caught “Other Flatfish” (which includes sanddabs) during the past decade, indicating a stable and likely reasonably utilized resource (Leet et al. 2001).

<u>California Sheephead</u> (*Semicossyphus pulcher*)

Although the sheephead ranges from Monterey Bay, California to the Gulf of California, it is not common north of Point Conception (Leet et al. 2001). It is a protogynous hermaphrodite, beginning life as a female with older, larger females developing into secondary males. Female sexual maturity may occur in three to six years and fishes may remain female for up to fifteen years (Leet et al. 2001). Timing of the transformation to males involves population sex ratio as well as size of available males and sometimes does not occur at all. The sheephead is a rocky reef, kelp bed species found to depths of 280 feet (Leet et al. 2001).

The largest commercial catches of California sheephead were from 1927 to 1931, peaking in 1928 at more than 370,000 pounds. During and shortly after World War II (1943-1947), the sheephead catch increased from 50,000 to 267,00 pounds, probably because of easy availability close to port. Since the 1940s and until the late 1980s, the average annual landing has been about 10,000 pounds. Between 1989 and 1990, the catch quadrupled and reached a peak in 1997 of 366,000 pounds and a market value of $840,176. During 1994 to 1999, the live catch varied between 87.8 percent and 73.7

percent of the total sheephead landings. The catch has decreased from 1997 to 1999, but the market value has remained high (Leet et al. 2001).

The estimated recreational catch of sheephead between 1983 and 1986 averaged 312,400 pounds with a maximum estimate of 448,800 pounds for 1986. Commercial passenger fishing vessel data from 1947 to 1998 indicate an average take of 28,030 fish per year with a maximum in 1983 of about 69,000 fish (Leet et al. 2001). Using an average weight of two pounds per fish (a low estimate) the sport catch, except in the cited maximal periods, often exceeds the commercial catch. During the 1930s, sheephead were considered “junk fish” by most recreational anglers and were not kept because of their soft flesh. However, the large size, fine flavor, and use as a lobster substitute in salads and other recipes has more recently made them a preferred and even targeted species by anglers and divers (Leet et al. 2001).

There has been no ongoing analysis of the status of the California sheephead (Leet et al. 2001). Long-term studies at two localities in southern California, Palos Verdes Point and the King Harbor breakwater, have shown that the species was not abundant in the cool period of the early 1970s (Leet et al. 2001). The population increased at both sites with the onset of the little El Niño of 1977-1978. At King Harbor, the population peaked in 1978, decreased through the end of the great El Niño of 1982-1983, and remained low until the early 1990s when it again reached a large size (1994 and 1998) (Leet et al. 2001). With the exception of 1982-1983 El Niño, the population seems to increase during El Niño conditions and this is reflected in increased recruitment. At Palos Verdes, the population peaked in 1981, then declined until 1983, but has remained relatively stable since (Leet et al. 2001). At maximum, the density of sheephead at the Palos Verdes kelp bed was three times that of the King Harbor breakwater. There is no evidence from these very limited data that the population is threatened by existing fishery practices (Leet et al. 2001).

<u>California Scorpionfish (sculpin)</u> (*Scorpaena guttata*)

California scorpionfish live from tide-pool depths to about 600 feet (usually in about 20-450 feet) from Santa Cruz to southern Baja California, and in the northern part of the Gulf of California (Leet et al. 2001). Preferring warmer water, the species is common as far north as Santa Barbara. While they are most abundant on hard bottom (such as rocky reefs, sewer pipes and wrecks), they are also found on sand (Leet et al. 2001). California scorpionfish grow to 17 inches and some live at least 21 years (Leet et al. 2001). After four years of age, females grow faster than males and reach a larger size. Although a few fish mature at six inches (one year), over 50 percent are mature by seven inches (two years) and all reproduce by nine inches (four years) (Leet et al. 2001).

The California scorpionfish (Scorpaena guttata) is a valuable commercial fish in southern California. For many years, the fishery experienced a long decline, with peak catches of 223,000 pounds in 1925 and fluctuating catches thereafter. However, the rise of the live fish fishery in the 1990s led to the fishery¡|s resurgence, as this species’ bright red color and hardiness after capture has made it a favorite target (Leet et al. 2001). Today, about 85 percent of the commercial California scorpionfish catch goes to the live fish fishery. Catches in 1998 totaled about 75,000 pounds valued at $175,000 (Leet et al. 2001). Most fish are taken in traps or by hook-and-line. California scorpionfish are a moderately important part of the sport fishery in southern California. They are taken primarily from party boats and private vessels, and occasionally from piers and jetties, mostly from Point Mugu southward (Leet et al. 2001).

No population estimates exist for California scorpion fish (Leet et al. 2001). However, data from trawl studies conducted by the Los Angeles County Sanitation Districts, Southern California Coastal Water Research Project and the Orange County Sanitation District from 1974-1993 show that there are substantial short-term fluctuations in California scorpion fish abundance within the Southern California Bight (Leet et al. 2001).

Giant (Black) Sea Bass (*Stereolepis gigas*)

In the eastern Pacific, giant sea bass range from Humboldt Bay to the tip of Baja California, and occur in the northern half of the Gulf of California (Leet et al. 2001). Within California it is rarely found north of Point Conception (Leet et al. 2001). Adult giant sea bass seem to prefer the edges of nearshore rocky reefs. These reefs are relatively shallow (35 to 130 feet) and often support thriving kelp beds (Leet et al. 2001). Although the kelp may disappear due to a strong El Niño or overgrazing by sea urchins, giant sea bass remain at the reef. Although aging data are sparse, it is safe to say these fish grow slowly and live a long time. Estimated growth-rates are six years to reach 30 pounds, 10 years to reach 100 pounds, and 15 years to reach 150 pounds (Leet et al. 2001).

Because giant sea bass grow slowly and mature at a relatively old age, they are susceptible to overfishing. As a consequence, they have suffered a serious decline in numbers. Commercial landings from U.S. waters peaked in 1932 near 200,000 pounds before declining (Leet et al. 2001). Mexican waters were more productive (peaking at over 800,000 pounds in 1932) and did not permanently sink below 200,000 pounds until 1964 (Leet et al. 2001). A few hook-and-line fishermen targeted giant sea bass, but they were also caught incidentally by gillnets set for halibut and white sea bass.

Recreational landings, reported in numbers of fish rather than pounds, show a similar trend of peaking and permanently declining. The peak in California landings occurred in 1963 while Mexican landings peaked in 1973 (Leet et al. 2001). The later peak in the recreational fisheries compared to the commercial fishery is due to the later development of the recreational fishery rather than a reflection of the giant sea bass population (Leet et al. 2001). A few boats developed a special recreational fishery targeting spawning aggregations during the summer months. Trips made in July to certain reefs between Point Abreojos and Magdalena Bay, Baja California, consistently produced 70 to 100 giant sea bass. One trip produced 255 in three days (Leet et al. 2001). Once these aggregations were targeted the fishery disappeared with the fish.

In 1981, a law was passed that prohibited the take of giant sea bass for any purpose, with the exception that commercial fishermen could retain and sell two fish per trip if caught incidentally in a gillnet or trammel net. This law also limited the amount of giant sea bass that could be taken in Mexican waters and landed in California. A vessel could land up to 1,000 pounds of Mexican giant sea bass per trip but could not land more than 3,000 pounds in a calendar year. The law was amended in 1988, reducing the incidental take to one fish in California waters. Although this law may have prevented commercial fishermen from selling giant sea bass in California, it did not prohibit fishing over habitats occupied by this species and probably did little to reduce the incidental mortality of giant sea bass, as giant sea bass that were entangled in the nets were discarded at sea. The 1981 rule changes were more effective in protecting giant sea bass in Mexico, since large landings had been historically made by hook-and-line fishermen targeting grouper, cabrilla, and giant sea bass off the Pacific coast of Baja California. The banning of inshore gillnets displaced the California fishery from the majority of areas inhabited by giant sea bass; it is reasonable to assume that this closure significantly reduced the incidental mortality of giant sea bass in California.

The California population of giant sea bass is well below historical highs. Anecdotal information suggests that numbers may be beginning to rebound under current measures (Leet et al. 2001). No hard data exist that provide actual or relative numbers of giant sea bass (Leet et al. 2001).

<u>Kelp (Calico) Bass</u> (*Paralabrax clathratus*)

Kelp bass have ranged historically as far north as the mouth of the Columbia River and south to Bahia Magdalena, Baja California, Mexico. However, they are rare north of Point Conception (Leet et al. 2001). They are abundant in southern California waters including the shores of all the Channel Islands (Leet et al. 2001). They are typically found in shallow water (surface to 150 feet) being closely associated with high relief structure, including kelp. Kelp bass range throughout the water column, but seem to concentrate between eight and 70 feet (Leet et al. 2001). Kelp bass are known to grow to 28.5 inches and 14.5 pounds. The oldest known kelp bass was 34 years old and 25 inches long. Juvenile kelp bass can be five to six inches after one year and are about 12 inches (legal size) at five years. The average 10 year-old kelp bass is about 18 inches in total length (Leet et al. 2001).

This important species has been the target of southern California anglers and commercial fishermen since the early 1900s (Leet et al. 2001). In the early years of the fishery, catch statistics grouped kelp bass and the two other Paralabrax species, barred sand bass and spotted sand bass, into a single “rock bass” category. Based on recent information, it is very likely that kelp bass comprised most of this catch category early on (Leet et al. 2001). The largest commercial landings of rock bass occurred during the 1920s and 1930s; annual landings averaged 500,000 pounds. A sharp decline in fishing activity occurred during and after World War II and landings never exceeded 150,000 pounds from 1941 through 1953. The general decline of the rock bass resource prompted conservation measures, which in 1953 made commercial fishing for rock bass illegal in California waters (Leet et al. 2001).

The recreational kelp bass catch has fluctuated greatly since the 1960s (Leet et al. 2001). The largest CPFV catches occurred during the mid-1980s, estimated at over 1,000,000 fish annually. Since 1980, the CPFV kelp bass catch has ranged from 273,000 to 2,795,000 fish in 1988 and 1986, respectively, and averaged about 1,000,000 kelp bass per year. CPFV landings of kelp bass typically peak in the late spring and early fall. The recent RecFIN Survey estimated that since 1990 the catch from shore, pier, and private boat anglers averages about 900,000 kelp bass per year which exceeds that of CPFV fishermen (about 800,000 fish per year). The CPFV landings of kelp bass steadily declined each year from 1993 to 1999 (Leet et al. 2001). The Channel Islands are one of the most productive areas for recreational kelp bass fishing (Leet et al. 2001).

In the 1970s and 1980s, the kelp bass was among the top three species taken by the average angler per hour of fishing (along with barred sand bass and Pacific mackerel) (Leet et al. 2001). In 1986 and 1989, kelp bass were the most commonly taken species in the CPFV fleet. Throughout the 1980s, kelp bass have consistently ranked among the top five fishes caught by CPFV anglers (Leet et al. 2001). DFG surveys indicate the estimated total catches of kelp bass have increased since the mid-1970s. Low periods of kelp bass landings in the mid-1970s and early-1980s may be attributed to El Niño events that provide anglers with alternative species to catch. Peak landings have followed each El Niño event. DFG surveys of the CPFV industry in the 1970s and 1980s indicated a stable spawning population is being maintained because of the large number of age classes that are caught and kept by anglers (Leet et al. 2001). Approximately 85 percent of the kelp bass kept by CPFV anglers measure between 11.4 to 15.9 inches, representing up to seven age classes. However, the alarming decline of recreational catch from all sources that has occurred in the 1990s is a major cause for concern (Leet et al. 2001).

Barred Sand Bass (*Paralabrax nebulifer*)

Barred sand bass range from Santa Cruz south to Bahia Magdalena, Baja California, Mexico (Leet et al. 2001). They are rare north of Point Conception. Sand bass chiefly inhabit the shallow waters near the southern California mainland, but have been captured at depths as great as 600 feet, but the greatest concentrations are found in depths less than 90 feet (Leet et al. 2001). Young sand bass are abundant in very shallow water (five to 30 feet) (Leet et al. 2001). The name “sand bass” is somewhat inappropriate since they are usually closely associated with sand/rock interfaces of deep reefs and artificial structures and are rarely found out over sandy expanses. their sympatric congener the kelp bass, barred sand bass are also relatively slow growing. A juvenile barred sand bass is approximately six inches long after one year, and reaches sexual maturity between seven and 10.5 inches in length and about three to five years (Leet et al. 2001).

Barred sand bass are targeted exclusively by sport anglers; the commercial harvest of this species has been illegal since 1953. Throughout the 1930s and early 1940s, sand bass, as well as kelp bass, were not considered to be quality angling fare but gained tremendously in popularity as game fishes by the mid-1950s (Leet et al. 2001). At that time, concern about the resource by sport fishermen and fishery managers resulted in the initiation of life history studies and the formulation of conservation measures. By 1959, a 10-fish bag limit and a 12-inch minimum size limit had been imposed on all three kelp and sand bass species, measures designed to counteract the declining numbers, and shrinking size composition of the bass catches. In 1985, 1987 and 1988, barred sand bass was the leading bass species in the CPFV catch exceeding kelp bass landings for the first time since 1961 when kelp bass and sand bass landings were first reported separately (Leet et al. 2001). Estimates of annual barred sand bass landings from all sport fishing activities (shore, pier, private boat, CPFVs, etc.) ranged as high as 1,940,000 in 1988 (Leet et al. 2001). The CPFV landings of barred sand bass remained stable at around 600,000 fish from 1993 to 1996, but declined dramatically thereafter. On average, landings of barred sand bass in the 1990s were about 40 percent lower than those in the 1980s (Leet et al. 2001).

Surfperches (Family Embiotocidae)

The surfperches are a small abundant assemblage of 23 species found predominantly in temperate eastern North Pacific waters. Nineteen of the 20 species found in California occur in inshore coastal waters (Tuleperch, *Hysterocarpus traski*, occupies freshwater and estuarine habitats). Collectively, the 19 marine species are found in a variety of habitats, including beaches, rocky substrate, intertidal and subtidal kelp beds. A few species inhabit several of the habitat types. Included in this group are the pile perch (*Rhacochilus vacca*), rubberlip surfperch (*R. toxotes*), shiner perch (*Cymatogaster aggregata*), walleye surfperch (*Hyperprosopon argenteum*), and the white surfperch (*Phanerodon furcatus*) (Leet et al. 2001).

The majority of surfperches occupy only one type of habitat. Species most commonly found along beaches include the barred surfperch (*Amphistichus argenteus*), calico surfperch (*Amphistichus koelzi*), redtail surfperch (*A. rhodoterus*), silver surfperch (*H. ellipticum*), and the spotfin surfperch (*H. anale*). Black perch (*Embiotoca jacksoni*), dwarf perch (*Micrometrus minimus*), kelp perch (*Brachyistius frenatus*), rainbow perch (*Hypsurus caryi*), reef perch (*M. aurora*), sharpnose seaperch (*Phanerodon atripes*), and striped seaperch (*. lateralis*) tend to be associated with rocky substrate and kelp beds. The pink seaperch (*Zalembius rosaceus*) inhabits deep water (Leet et al. 2001).

Annual commercial landings of surfperches have been highly variable. While the market for fresh "perch" fillets is relatively small, the total catch for the fishery was 49,000 pounds in 1999 (Leet et al. 2001). The Department did not distinguish between species in their statistics until 1987, simply listing the category as surfperch. Currently, there is a large commercial fishery for various surfperches in the southern part of the State and a moderate fishery focusing on redtail surfperch in northern California (Leet et al. 2001).

The sport fishery is enjoyed by anglers of all ages who fish for surfperch from piers, jetties, sandy beaches, and boats. The recreational catch of surfperch for 1999 totaled 489,000 fish, with the majority being caught in central and northern California (Leet et al. 2001). The average sport catch for 1993 through 1999 was 864,000 fish with a high of 1,119,000 fish in 1998 (Leet et al. 2001). Most of the California coastal species taken in the sport catch are taken when spawning aggregations are present. Female surfperches are intentionally targeted by sport anglers because they are larger than males (Leet et al. 2001). Sport anglers also grade their catch, which probably results in an even greater take of mature females with a resulting decline in the fishery (Leet et al. 2001).

The redtail and barred surfperches are the most notable in the commercial catch and may be important to local economies (Leet et al. 2001). Total commercial surfperch landings have fluctuated over the years, but over the long-term have declined by 25 percent since the 1950s (Leet et al. 2001). Recent research has indicated that some of the decline is associated with the increases in water temperature (Leet et al. 2001). Surfperch habitats have been, and will continue to be, areas of conflict. As humans develop the shoreline, areas inhabited by surfperches may become polluted or destroyed. Although surfperches may adapt to structures such as jetties and piers, it should not be assumed that they can continue to adapt to all the changes from human activities (Leet et al. 2001).

<u>Kelp Greenling</u> (*Hexagrammos decagrammus*)

Kelp greenling range from San Diego to the Aleutian Islands, but are common only north of Morro Bay (Leet et al. 2001). They are one of the most conspicuous fishes in northern rocky nearshore habitats occurring often in and around kelp beds. These solitary fish are common at depths between 10 and 60 feet, and range down to 150 feet (Leet et al. 2001). Kelp greenling grow faster than most nearshore fishes during their first three years. After the third year, growth slows, especially in males (as it does in lingcod), so that by the fifth or sixth year males are smaller than females. The maximum reported age and size in Washington is 16 years and 21 inches (Leet et al. 2001).

Commercial catch reported from 1981 to 1999 averaged about 8,500 fish per year (Leet et al. 2001). This average is somewhat exaggerated by exceptionally large numbers of fish landed commercially in recent years by the nearshore live fish fishery. From 1981 to 1996 average commercial catch was only around 5,500 fish per year, while from 1997 to 1999 that average increased to 27,400 fish per year (Leet et al. 2001). Until recently most of these fish were sold in the fresh-fish market, although now many are sold live to restaurants.

Sport fishing surveys made from 1958 to 1961 showed that kelp greenling were the most frequent catch of shore fishermen north of San Francisco, where in some areas they made up more than 30 percent of the total catch (Leet et al. 2001). In California, during those years, an average of 54,000 kelp greenling were caught by hook-and-line fishermen and another 2,000 by spear fishermen (Leet et al. 2001). In later surveys conducted from 1980 to 1999, the estimated sport catch averaged 106,650 fish per year, with 103,000 of those taken between Monterey County and the Oregon border (Leet et al. 2001). It should be noted that the two sport fishing surveys used different sampling designs, so results may not be comparable. In the Channel Islands they are taken occasionally.

There are no estimates of abundance for kelp greenling in California. The yearly sport catch remained relatively constant during the first ten years (1980-1989) it was surveyed, but has declined steadily from 1993 to 1999 (Leet et al. 2001). Since decline in catch is one symptom of overfishing, this may be an indication that current levels of fishing are having adverse effects on the population, although no population data are available at present to confirm this. Spear fishermen could overfish local populations, however, because they can select individual targets, and greenling are particularly vulnerable to spears when guarding their nests. Also, although commercial catch has been traditionally very low compared to recreational catch, the increased fishing pressure in recent years by the nearshore live fish fishery could have a much broader impact on the kelp greenling population in California (Leet et al. 2001).

Lingcod (*Ophiodon elongatus*)

Lingcod are distributed in nearshore waters from northern Baja California to the Shumagin Islands along the Alaskan Peninsula. Their center of abundance is off British Columbia, and they become less common toward the southern end of their range (Leet et al. 2001). They are found in the Channel Islands, especially in the colder water regions of San Miguel and Santa Rosa. Lingcod lack a swimbladder and thus will rest on the bottom or actively swim in the water column. They are found over a wide range of substrates at depths from 10 to 1,300 feet, but most occur in rocky areas from 30 to 330 feet (Leet et al. 2001). Typically, larger lingcod occupy rocky habitats; larger animals are found on deeper banks and reefs, whereas smaller animals live in shallower waters. Although there is large variation in length at age, the average one-year-old fish is 13 inches long, and a two-year-old is 17 inches long. After age two, females begin to grow faster than males. The average length of a four-year-old female is 24 inches, of an eight-year-old is 32 inches, and of a 12-year-old is 35 inches. The average length of a four-year-old male is 22 inches, of an eight-year-old is 29 inches, and of a 12-year-old is 32 inches. In California, the oldest lingcod on record is a 19-year-old, 45-inch female, and the longest is a 51-inch female (Leet et al. 2001).

Catches of lingcod have been reported as a separate category since 1916 in California. Commercial landings from 1916 through 1929 ranged from 400,000 pounds to 1.2 million pounds. Landings in the first half of the century reached a peak in 1930 at 1.3 million pounds, and then declined to a low of 314,000 pounds in 1942. The California lingcod fishery grew again from 1943 through 1950, as landings ranged from 719,000 pounds to a high of 2.1 million pounds in 1948, due primarily to strong markets for liver oil and seafood. For the next two decades, landings averaged 1.2 million pounds per year, and then began to increase in the 1970s, due to the burgeoning west coast trawl fishery (Leet et al. 2001).

During this period of rapid fishery growth, lingcod landings in California almost tripled. From 1972 through 1982, commercial landings of lingcod averaged almost three million pounds per year. After a decline in the mid-1980s, landings rebounded to a high level again in 1989. Since then, however, commercial catches have rapidly declined, partly due to management restrictions enacted to rebuild depressed stocks. In 1999, commercial landings were only 313,000 pounds (Leet et al. 2001) .

Recreational landings as a percentage of total lingcod landings increased from 20 percent in the 1970s to about 50 percent in the late 1990s. This was because recreational fishing effort in California increased by 65 percent between the time periods 1958 through 1961, and 1980 through 1986 (Leet et al. 2001). Average annual landings in the California recreational fishery almost doubled during that period, from 510,000 pounds per year to 890,000 pounds per year (Leet et al. 2001). The increase was due largely to an increase in the private boat fishery. In 1961, 61 percent of the recreational landings came from commercial passenger fishing vessels. Now, 70 percent of the recreational landings come from the private boat fishery (Leet et al. 2001). In both the commercial and recreational fisheries, landings occur predominately in central and northern California.

Lingcod harvest has been higher than generally accepted population replacement rates for the last twenty years. Recent lingcod stock assessments have concluded that the lingcod stock is seriously depleted, and that California populations appear to be less than 25 percent of their pre-1970s level (federally designated as overfished). By Federal law, this level of stock depletion requires a management plan that rebuilds lingcod populations. The rebuilding plan is intended to restore the lingcod stock within 10 years. The substantial reduction in Allowable Biological Catch (ABC) after 1997 and resulting reduced fishery harvest was triggered by that rebuilding plan. Low levels of ABC and harvest will continue until lingcod populations show signs of rebounding. California lingcod appear to be highly productive, however, and there is good potential for rapid population increases given appropriate decreases in fishing effort (Leet et al. 2001).

<u>Monkeyface Prickleback (Eel)</u> (*Cebidichthys violaceus*)

The monkeyface prickleback, also know as monkeyface eel, ranges along the Pacific coast from San Quentin Bay, Baja California, Mexico to central Oregon (Leet et al. 2001). It is most common off central California from San Luis Obispo County to Sonoma County, and is uncommon south of Point Conception. They normally occur in the intertidal zone with a depth range extending from the high intertidal to a reported depth of 80 feet (Leet et al. 2001). Typical habitat for monkeyface prickleback includes rocky intertidal areas with ample crevices, boulders, and algal cover, including high and low tide pools, jetties and breakwaters, and shallow subtidal areas, particularly rocky reefs and kelp beds. Juveniles are particularly adapted for living in the high intertidal zone. The species is capable of living out of water under algae for extended periods and has air-breathing capacity. Monkeyface prickleback grow slowly, particularly after the first few years of life. A 12-inch fish is approximately three years old, while a 24-inch fish will be 15 to 17 years old (Leet et al. 2001).

Commercial landing records in California date from 1928. Catch since then can best be described as of minor significance. Since 1991, annual landings have ranged from 12 to 935 pounds, primarily from the port areas of San Francisco and Santa Barbara (Leet et al. 2001). However, catch statistics may include California moray, rock prickleback, wolf-eel, and other eel-like fishes or true eels.

A specialized recreational fishery by shore anglers fishing in rocky intertidal and shallow subtidal habitat exists for this species. The most common fishing method is “poke poling,” which normally consists of fishing with a long bamboo pole, a short piece of wire, and a baited hook. The bait is placed in front of or in holes or crevices in the rock. Skin and scuba divers also spear them. The monkeyface prickleback did not rank among the top fifteen species observed in either beach/bank or jetty/ breakwater MRFSS fishing categories from 1980 through 1986 in California. The most recent (1999) MRFSS total catch estimate for northern California from all recreational fishing categories was 2,000 fish; however, the standard error of the estimate was much higher than the estimate.

No information is available on the status of stocks of monkeyface prickleback (Leet et al. 2001). The primary source of fishing mortality is from recreational poke polers and commercial anglers fishing from shore or the shallow subtidal, with a lesser number taken spearfishing by free and scuba divers. Historically, both recreational and commercial landings are considered to be low (Leet et al. 2001).

<u>Leopard Shark</u> (*Triakis semifasciata*)

The leopard shark ranges from Mazatlan, Mexico, into the northern Gulf of California, and northward to Oregon (Leet et al. 2001). It is most common in shallow water from the intertidal down to 15 feet, less so down to 300 feet or deeper in ocean waters (Leet et al. 2001). Favoring muddy bays and sloughs, especially in northern California, it is known to move out and in with the tides to feed over shallow tidal mudflats. It also occurs along the open coast and around offshore islands off southern California, where it frequents kelp beds, sandy bottoms near rocky reefs, and the surf zone along sandy beaches. The maximum recorded and verified total length is about six feet long. The oldest validated age that has been determined by reading tetracycline-labeled rings on the vertebrae, is 26 years for a 49-inch female, an average of 1.8 inches per year (Leet et al. 2001). Size at birth is about eight to 10 inches in total length. Longevity is presumed to be around 30 years (Leet et al. 2001).

The leopard shark is taken as both a food and game fish in California, and its distinctive markings and hardiness also make it desirable for aquarium displays. Although some commercial landings may be lumped under a general “shark, unspecified” category, those reported as “leopard shark” have ranged from 9,270 pounds in 1958, to a high of 101,309 pounds in 1983 (Leet et al. 2001). These landings, while not extensive, increased in the south and decreased in the north during the 1980s. Landings in southern California began increasing in 1981, and in 1985 surpassed landings in northern California for the first time since the collection of statistics began in the 1940s (Leet et al. 2001). Since 1991, landings have averaged about 31,000 pounds per year, with about 57 percent of the landings occurring south of Point Piedras Blancas (Leet et al. 2001). Legislative curtailment of inshore gillnetting in the San Francisco/Monterey Bay area undoubtedly contributed to much of the decline in northern California landings after 1986.

Judging from MRFSS estimates made since 1980, the recreational leopard shark catch appears to be greater than the commercial catch, although these estimates are subject to large sampling variability. According to the survey, sport catches in California between 1980 and 1988 averaged over 52,000 fish per year with a low of 33,000 fish taken in 1980 and a high of 59,000 fish taken in 1988. Since 1993, an estimated average of 45,000 leopard sharks have been taken by anglers, with a low of 34,000 taken in 1993 and again in 1994, and a high of 58,000 taken in 1997 (MRFSS).

The size of the California leopard shark population has not been estimated, and the only information on relative changes in stock abundance is what can be inferred from catch statistics. Because of its rather limited geographical range with little exchange among regional stocks within this range, resident stocks near large population centers may be particularly vulnerable to heavy localized fishing pressure. A recent re-assessment of the leopard shark's intrinsic productivity and vulnerability to harvest revealed it to be even more susceptible to overexploitation than previously reported (Leet et al. 2001). Its annual rate of increase under maximum sustainable yield exploitation has been calculated at only about two to three percent per year. And while the size limit protects juveniles, it does not protect mature adults in their prime reproductive years in feeding and near shore pupping areas.

<u>Pacific Angel Shark</u> (*Squatina californica*)

The Pacific angel shark is reported to occur only in the eastern Pacific Ocean from southeastern Alaska to the Gulf of California and from Ecuador to Chile (Leet et al. 2001). A gap in distribution separating subpopulations of *S. californica* occurs between the equator and 20° North latitude (Leet et al. 2001). The southern population was earlier reported as a separate species, *S. armata*. In the Santa Barbara Channel, commercially caught specimens generally range in size between three and four feet, although minimum size limits now allow the take of females 42 inches and above and males 40 inches or more (Leet et al. 2001). Angel sharks range in depth from three to over 600 feet (Leet et al. 2001). Fishermen working the northern Channel Islands reported that most of their catches were between 30 and 240 feet. After the inshore area closures were set in 1994, fishing shifted to deeper waters between 100 and 300 feet (Leet et al. 2001). Pacific angel shark are usually found lying partially buried on flat, sandy bottoms and in sand channels between rocky reefs during the day, but they may become active at night.

Discarded as a nuisance species by halibut gillnet fishermen for several decades, the Pacific angel shark became one of the most sought after commercial shark species in the Santa Barbara Channel during the 1980s (Leet et al. 2001). Changes in consumer acceptance of sharks as high quality food fish and a concentrated marketing effort by an innovative processor working with local fishermen, stimulated development of the angel shark fishery in the Santa Barbara Channel area in 1976 (Leet et al. 2001). In 1977, landings of dressed angel shark totaled 328 pounds. By 1981, landings rose to 258 thousand pounds, and by 1984, to 610 thousand pounds. Landings of angel shark exceeded one million pounds annually in 1985 and 1986, replacing the thresher shark as the number one species of shark taken for food in California. Landings began to decline in 1987, dropping to 940 thousand pounds and further declining to 248 thousand pounds in

1990 (Leet et al. 2001). A minimum size limit adopted by the Department in 1986 contributed to a decrease in landings in the following years. A second major decline in landings occurred in 1991 when a voter initiative was passed banning the use of gill and trammel nets within three miles of the southern California mainland coast and within one mile around the Channel Islands. Many gillnetters switched to other fisheries and a few dropped out entirely or retired. In 1990, a total of 144 vessels (including a few trawlers) landed angel shark and by 1994, the number was reduced 50 percent to 72 (Leet et al. 2001). These boats landed 23 thousand pounds, a decline of 91 percent from the catch in 1990. Of the 72 vessels reporting landings, nine boats landed the major share (61 percent) (Leet et al. 2001). The closures, in effect, established a large "no-take" reserve for angel shark in southern California, since gillnetting, considered to be the most viable fishing method for this species, was eliminated in the primary nearshore angel shark habitat.

There has been little recreational interest in angel shark as nearshore anglers using hook-and-line catch relatively few compared to other more active sharks (Leet et al. 2001). One study logged only 12 angel sharks compared to over a thousand other sharks landed between 1997 and 2000. Nearly all of the angel sharks were caught at night (Leet et al. 2001).

No population studies have been conducted on angel shark since the nearshore fishery ended in 1994 (Leet et al. 2001). A comparative research survey of nearshore fish assemblages around Santa Catalina Island and along the mainland (Santa Barbara to Newport Beach) between 1996 and 1998 indicated that Squatina was a commonly caught species at many of the 10 sampling stations (Leet et al. 2001). The researchers reported that the survey showed a greater abundance and proportionately larger biomass for nearshore sharks than any other southern California study. Further, they note that gillnets are much more efficient for sampling mobile and elusive fishes than trawls and diver surveys. In terms of biomass, angel sharks ranked third at Santa Catalina Island and ninth at the mainland sites. There have been no recent studies of Squatina populations at the northern Channel Islands (Leet et al. 2001).

Skates and Rays

Skates and rays are not specifically sought by commercial fishermen, but are taken incidentally, primarily by bottom trawlers in central and northern California waters (Leet et al. 2001). Of the species identified in the commercial catch the most common are the shovelnose guitarfish (*Rhinobatos productus*), bat ray (*Myliobatis californica*), big skate (*Raja binoculata*), and thornback (*Platyrhinoidis triseriata*). This does not represent the true catch composition, however, as 98 percent of the landings are listed as "unidentified skate" (Leet et al. 2001). A few nearshore species, most commonly the bat ray and shovelnose guitarfish, are the target of small sport fisheries.

Rays and skates occur in all marine habitats, from protected bays and estuaries to open seas, ranging from the surface to 9,500 feet deep (Leet et al. 2001). While some species are common, others are known from only a few specimens. From 1916 to 1990, skate landings, which ranged from 36,247 pounds (1916) to 631,240 pounds (1981), comprised two to 90 percent of the total elasmobranch catch (11.8 percent average) (Leet et al. 2001). Like the shark fishery, which had peaks from 1937 to 1948, and more recently from 1976 to 1990, the skate catch has fluctuated widely during the last half century (Leet et al. 2001). In the past 10 years, however, skate and ray landings have increased nearly ten-fold in California, from around 228,566 pounds in 1989 to 1,912,695 pounds in 1999 (Leet et al. 2001). This trend is most notable in the trawl fishery after 1994.

Some of the apparent increase may be due to increased landings of previously discarded catch. In 1994, the commercial groundfish fishery was divided into limited entry and open access components, each with new regulations and quotas. Groundfish quotas for both components were significantly reduced in the period from 1994 through 1999, leaving more space in the boats' holds for non-quota species. Trawl vessels may have supplemented their groundfish landings with skate and ray bycatch. There is considerable uncertainty whether the total impact on the skate and ray resource has increased or if more of the catch is being retained and landed (Leet et al. 2001).

The impact of sport fisheries on skates and rays is relatively unknown. Data from 48 shark derbies in Elkhorn Slough from 1950 to 1990 show, however, that shovelnose guitarfish, which in the 1950s and 1960s were the second, and in some years the most abundantly caught elasmobranch, virtually disappeared from the catch in later years (Leet et al. 2001). In the 1990s, there was a two-thirds decrease in the catch-per-unit effort for bat rays compared to the 1950s catch rates in these derbies (Leet et al. 2001). MRFSS data, however, show continued catches of bat rays, big skates, shovelnose guitarfish, and thornback. The total numbers caught are hard to determine from the numbers of sampled skates and rays, as sampled catch numbers vary widely from year to year (Leet et al. 2001).

Based on existing data, little can be said about the current or past population levels of California's skates and rays (Leet et al. 2001). While landings are increasing dramatically, this may or may not reflect an actual threat to the resource. Fish that were discarded in the past, dead and alive, are now being retained and landed. Other regions have already witnessed decreases in skate and ray populations and the population status warrants close monitoring.

Nearshore Epipelagic Species

California Barracuda (*Sphyraena argentea*)

The California barracuda is a nearshore, epipelagic, schooling fish found from Cabo San Lucas, Baja California to Kodiak Island, Alaska (Leet et al. 2001). Catch origins indicate the population is centered between San Quentin, Baja California and Point Conception, California. During warm water oceanic events, such as El Niños, a portion of the population may shift northward into central California (Leet et al. 2001). Frequently seen at the surface, barracuda have been taken at depths of 120 feet. California barracuda have an inshore distribution during their early life history. Fish a few inches long are observed in protected bays and marinas. Larger young-of-the-year fish school below the canopy of semi-protected kelp-bed habitats. Older juveniles and adults form large schools that disperse widely in the open-water environment (Leet et al. 2001).

Annual records of commercial barracuda landings date back to 1889, but only nine years of intermittent records exist through 1915, and these are not specific as to catch areas (Leet et al. 2001). Commercial landings of barracuda in 1889 were 0.5 million pounds, and by 1915 they were up to 3.6 million pounds. Since 1916, landing records have differentiated barracuda caught in California waters (essentially off southern California) from those caught in waters south of the international border with Mexico (northern Baja

California). By 1916, The southern California purse seine fleet consisted of at least seven vessels by 1916 (Leet et al. 2001). Influenced by the economic impetus of World War I, the commercial barracuda fishery grew concurrently with the rapid development of the purse seine fleet.

Between 1915 and 1970, commercial landings of barracuda harvested from California's nearshore waters averaged 2.1 million pounds annually, despite a gradual decline in landings since 1925 (Leet et al. 2001). Landings have remained relatively low since 1970, averaging about 113,500 pounds annually. Prior to 1926, California barracuda harvested south of the international border exceeded those catches made in California. Barracuda harvest from Mexican waters remained an integral part of the California fishery until 1969, averaging over one million pounds annually. But over the past 30 years, landings have been insignificant, averaging only 600 pounds annually. The major cause for the decline was the imposition of increasingly restrictive commercial fishing regulations by Mexico which became increasingly restrictive to California fishermen over the years (Leet et al. 2001).

As interest in marine sport fishing grew in the post-World War II era, the sport take of barracuda greatly exceeded that of the commercial fleet in California waters (Leet et al. 2001). Between 1946 and 1971, CPFV barracuda landings ranged from 87,600 to 1.2 million fish, for an overall annual average of 447,000 fish. In 1971, the current 28-inch minimum size limit for all sportcaught barracuda became effective, causing an 86 percent decline in CPFV barracuda landings from the previous year. Since 1971, CPFV landings of barracuda have been increasing, ranging between 26,300 and 446,000 fish annually (Leet et al. 2001).

The status of the California barracuda population is unknown, because data concerning catch, fishing effort, and age composition are scarce. Barracuda catches off California are variable for many reasons, one of which is that barracuda are migratory with a preference for warmer waters. During an El Niño event, when warmer than normal water masses move up the coast, barracuda are caught far north of their normal range and in greater than average numbers off southern California, suggesting a higher population level (Leet et al. 2001).

<u>Pacific Bonito</u> (*Sarda chiliensis*)

Bonito is a temperate epipelagic schooling fish with a discontinuous distribution in the eastern Pacific Ocean. It ranges from Chile to the Gulf of Alaska, but is absent from the central coast of Mexico south to Panama (Leet et al. 2001). The northern population typically is centered between southern California and central Baja California, but this distribution can shift northward during warm-water years. Pacific bonito is a rapidly growing piscivorous fish. In one year this fish can reach roughly 20 inches in fork length, and weigh about four pounds. At two years of age, bonito average roughly 25 inches in fork length and weigh about eight pounds. Their growth slows in the latter half of life with the fish reaching 32 to 35 inches and 17 to 22 pounds at six years (Leet et al. 2001).

Over the last 80 years, commercial landings of bonito have ranged between 127,600 pounds (1956) and 31.9 million pounds (1975) (Leet et al. 2001). During the first half of the twentieth century, landings of bonito gradually increased from about 500,000 pounds in 1916 to around 10.9 million pounds in 1941. Landings briefly peaked again after World War II, but dropped during the 1950s and early 1960s. Landings then showed a major upward trend from the mid-1960s through the mid-1970s, increasing more than four-fold between 1965 and 1975. Starting in the late 1970s, this trend reversed with landings dropping in the 1980s to a decadal average of eight million pounds (compared to 9.7 million pounds for the 1960s and 17.7 million pounds for the 1970s). In the 1990s, landings for this fish ranged between 157,000 and 9.58 million pounds with a decadal average of 1.9 million pounds. This average was higher than that observed in the 1950s (1.8 million pounds) but lower than those from the previous three decades. In the 1990s, bonito's ranking among the other commercial species also dropped. By total weight, bonito ranked among the top 20 species landed by California fisheries for most of the 1980s. In contrast, during the 1990s, this fish ranked among the top 20 species only in 1990 and 1998 (Leet et al. 2001).

As a result of the expansion of the commercial passenger fishing vessel (CPFV) industry after World War II, Pacific bonito catches by CPFVs increased from 36,500 in 1947 to over one million fish in 1960. Most of these fish were caught between Malibu Beach and the Coronado Islands.CPFV logbook landings of bonito remained high during the 1960s, with more than one million fish taken in 1964, 1968, and 1969. However, in the 1970s and 1980s, CPFV landings dropped and then stabilized with decadal averages for the 1970s and 1980s at 313,200 and 372,700 fish, respectively. In the 1990s, the number of fish taken by CPFVs dropped again. Logbook landings ranged between 2,880 and 263,000 fish with a decadal average of 101,700. The 1999 landings were the lowest annual catch on record and the decadal average the lowest since the 1940s (Leet et al. 2001).

During the 1980s, more then one-half of the bonito catch was made from private boats as this method of angling became increasingly popular. A similar trend was observed in the 1990s with private boats landing between 33 percent and 57 percent of the recreational catch. Private boat landings in the 1990s ranged between 1,200 and 128,400 fish with a decadal average of 49,600. This was significantly lower than the 1980s decadal average of 560,000 fish. Recreational catches can be impacted by the availability of other desirable species. In the 1980s and 1990s, highly desirable species such as yellowfin tuna, bluefin tuna, and albacore occasionally were available in large numbers. The reductions in recreational landings of bonito can be attributed in part to a shift in targeted effort from bonito to these more desirable species (Leet et al. 2001).

Warm water conditions in the 1980s and 1990s may have provided good conditions for bonito survival, but large catches have been sporadic and the trends in both commercial and recreational landings continue downwards. This downward trend may be due in part to a shift in targeted effort from bonito to other more desirable species and to low market demand. It also may be due to changes in the distribution and migration of this northern population in response to oceanographic changes that have taken place over the last two decades. However, this downward trend may well be due to a decline in stock abundance. If this is the case, then current fishing practices may make it difficult for this stock to rebuild (Leet et al. 2001).

<u>White Seabass</u> (*Atractoscion nobilis*)

White seabass range from Magdelena Bay, Baja California, Mexico to the San Francisco area. They are also found in the northern Gulf of California (Leet et al. 2001). During the strong El Niño of 1957-1959, seabass were reported as far north as Juneau, Alaska and British Columbia, Canada (Leet et al. 2001). The center of the white seabass population presently appears to be off central Baja California (Leet et al. 2001). Young-of-the-year white seabass, ranging in length from 0.25 inch to 2.25 inches, inhabit the open coast in waters 12 to 30 feet deep. They associate with bits and pieces of drifting algae in areas of sandy ocean bottom. Some time between the ages of one and three years old, they move into protected bays where they utilize eelgrass communities for cover and forage. Older juveniles are caught off piers and jetties and around beds of giant kelp. Adult seabass occupy a wide range of habitats including kelp beds, reefs, offshore banks, and the open ocean (Leet et al. 2001).

Commercial landings of white seabass have fluctuated widely over the nearly 85 years of record keeping. Almost three million pounds were reported in 1922, 599,000 in 1937, 3.5 million in 1959, and 58,000 in 1997 (Leet et al. 2001). Since 1959 the trend has been one of decline, although landings have been over 100,000 pounds for the years 1984 through 1991 and 1998-1999 (Leet et al. 2001). Although there was a commercial fishery in the San Francisco area from the late 1800s to the mid- 1920s, landings of fish caught north of Point Conception rarely exceeded 20 percent of the total California catch (Leet et al. 2001).

Recreational fishing for white seabass began around the turn of the century. Because of their size and elusive nature, seabass are popular with anglers. Historical records show that anglers on commercial passenger fishing vessels (CPFVs), fishing in California waters, landed an average of 33,400 fish annually from 1947 through 1959 (Leet et al. 2001). The catch steadily declined to an average of 10,400 fish in the 1960s, 3,400 fish in the 1970s, and 1,200 fish in the 1980s, but increased to 3,000 fish in the 1990s. In fact, the 1999 recreational catch of white seabass from California waters was greater than 11,000 fish and appears to be as high for 2000 (Leet et al. 2001). Additional seabass are caught by anglers aboard private boats, but accurate catches by private boat anglers are difficult to estimate.

Population estimates have not been made (Leet et al. 2001). Fishery biologists have been concerned about the decline in landings since the late 1920s. Human-induced changes, such as pollution, overfishing, and habitat destruction have probably contributed to this long-term population decline (Leet et al. 2001). However, natural environmental changes can also influence the population. The large numbers of small seabass caught in recent years suggests that the warm water period beginning with the 1982-1983 El Niño helped to increase young fish survival (Leet et al. 2001). Young fish surveys conducted in southern California, as part of OREHP, showed a dramatic increase in the number of fish taken in research gillnet sets. During research work in 1997 over 600 juvenile fish were captured, in 1998 approximately 700 fish were taken, and in 1999 slightly over 1,300 juveniles were captured (Leet et al. 2001). Anecdotal evidence from commercial and sport fishers confirms this dramatic increase in juvenile white seabass. It is unknown whether this increase in juveniles will continue to enhance the adult spawning population (Leet et al. 2001).

<u>Yellowtail</u> (*Seriola lalandi*)

Yellowtail are found from British Columbia, Canada to Mazatlan, Mexico. They are present in the Gulf of California, occurring as far north as the Bay of Los Angeles (Leet et al. 2001). The fishery usually occurs in nearshore areas, often adjacent to kelp beds. During the summer, fish may be found offshore under floating mats of kelp. Age and growth studies conducted on yellowtail indicate the fish are relatively slow growing. They gain approximately three to four pounds a year during most of their lives, although very large individuals may gain only one to two pounds per year (Leet et al. 2001). Growth can vary considerably from year to year and also between and within geographical areas (Leet et al. 2001).

Commercial landings of yellowtail have fluctuated greatly in the past, ranging from a high of 11.5 million pounds in 1918 to a low of 9,769 pounds in 1995. Market conditions appear to dictate landings more than does the health of the resource. When market demand for fresh yellowtail was high or the canneries needed fish because tuna were unavailable, the price to the fisherman was great enough to encourage trips for the fish (Leet et al. 2001).

In the 1950s private recreational boaters began taking a significant number of fish. During some years, private boaters land more yellowtail than do CPFV anglers. For instance, during 1997, private boat anglers fishing off California, landed 472,000 fish compared to 163,000 recorded by CPFV anglers. The increase in the number of private boat anglers may impact the yellowtail resource more than continued effort by CPFV anglers or commercial fishermen (Leet et al. 2001).

The 1996 year class dominated the sport fishery during the summer of 1997 as one-year-old fish. The 1996 year class remained off southern California during the winter of 1998 and again dominated the fishery as two year-olds. During 1998, the commercial fishery harvested almost a quarter million pounds of yellowtail since most of the 1996 year class fish reached legal size midway through the summer. This commercial catch represented a four-fold increase from 1997 (Leet et al. 2001). With the cooling of ocean waters off southern California in 1999 and 2000, sport and commercial yellowtail catches dropped. However, the 1996 year class continued to dominate the sport fishery during both years. Based on data from the MRFSS, the 1996 year class was the strongest in recent history. Over one million yellowtail from the 1996 year class were landed by CPFV and private boat anglers between 1997 and 2000.

Results of a Department tagging study indicate there are two stocks of yellowtail off Baja and southern California (Leet et al. 2001). One group occurs south of Cedros Island, Baja California, while the second group occupies the area from Cedros Island northward. There is some interchange of fish between the two groups around Cedros Island. Because of limited mixing between the two stocks, the southern California fishery is wholly dependent on fish recruited from the northern population (Leet et al. 2001).

Data collected during the 1970s and early 1980s indicate that the northern population has undergone a shift in fish size (Leet et al. 2001). Two and three year olds now dominate the catch, whereas six to nine year olds made up the majority of the catch in the past. The shift in size could be an indicator of either population stress or good recruitment (Leet et al. 2001).

Groundfish

Bocaccio (*Sebastes paucispinis*)

Bocaccio range from central Baja California to Kodiak Island, Alaska, and are common from northern Baja California to the Washington-British Columbia border (Leet et al. 2001). Larval bocaccio are initially pelagic and are most common within 100 feet of the sea surface. Adult Bocaccio are generally found on rocky reefs at depths of 250 to 750 feet. In some years, however, juveniles concentrate in shallow sandy areas near piers off central and southern California (Leet et al. 2001). Among rockfishes, bocaccio are noted for their relatively rapid growth, large adult size, and high variation in yearclass strength. They are known to attain a length of 36 inches, a weight of 15 pounds, and a maximum age of about 50 years. Some fast growing individuals are caught with trawl gear at age one, and substantial numbers are landed by age two at lengths of about 16 inches (Leet et al. 2001).

Before 1970, estimated landings by all fisheries averaged approximately six million pounds per year. Following 1970, combined landings increased, peaking in 1983 at over 15 million pounds. Landings have declined steadily since then, and fell below 0.5 million pounds in 1998. In 1978, nearly 40 percent of the sampled trawl landings contained half or more bocaccio by weight, but this value has declined to a very small percentage of landings in recent years (Leet et al. 2001). Estimated catches for the recreational fishery are available from 1980 onward and averaged 15 percent of the total landings in recent years. Recreational catches since 1984 have shown the same decline as the trawl fishery (Leet et al. 2001).

During the past two decades bocaccio landings have been dominated by the 1977, 1984, and 1986 year classes. A long string of recruitment failures occurred from 1989 to 1998, which under intense fishing led to a severely depleted population (Leet et al. 2001). By 1999, abundance had fallen to about three percent of the level seen in 1969, and the Pacific Fishery Management Council declared the population as “overfished.” Evidence from entrainment of young fish at the San Onofre Nuclear Generating Station indicates that the 1999 year class is large (Leet et al. 2001).

Cowcod (Sebastes levis)

Cowcod range from central Oregon to central Baja California, and offshore to Guadalupe Island. The geographic center of distribution is the southern California Bight (Leet et al. 2001). They are uncommon off Oregon and northern California. Adult cowcod habitat is primarily rocky reefs from 165 to 1,000 feet, most of which are found in the vicinity of offshore banks and islands in the Southern California Bight. Smaller fish generally occur at the shallower end of the depth range (Leet et al. 2001). Based on a sample of 259 specimens collected in the 1970s and 1980s, the youngest fish in the landings was age seven, and the oldest was age 55 (Leet et al. 2001). Cowcod are thought to become fully recruited to recreational and commercial fisheries at age 17, which is similar to the age at which all females become mature (Leet et al. 2001).

Cowcod are important to commercial and recreational fisheries in California. Estimated total catch peaked in 1976 at 213 tons, and then trended downward to 14 tons in 1999 (Leet et al. 2001). Recreational catch of cowcod exceeded commercial landings between 1959 and 1980 but commercial catch has been larger since. Recreational landings peaked in 1976 at 154 tons, and then declined to less than two tons from 1997 through 1999 (Leet et al. 2001). Commercial landings reached a record 155 tons in 1984. Fishing grounds nearest to major ports have been progressively targeted (Leet et al. 2001). Most of the remaining productive cowcod fishing grounds in the Southern California Bight are found well offshore, out-of-range for many private skiffs.

Cowcod were reported to be abundant off southern California in the 1890s (Leet et al. 2001). However, the first formal stock assessment of cowcod was in 1999 (Leet et al. 2001). Results of the assessment suggest that spawning biomass in 1916 was near the virgin level and it remained stable through a rather long historical period (1916-1950).

Biomass began to decline slowly in the 1950s and accelerated through the 1970s. Recruitment declined dramatically and biomass continued to decline after the early 1980s. The best estimate of cowcod spawning biomass in the Southern California Bight during 1998 is 262 tons, which is about seven percent of the estimated unfished stock size. Based on the results of the 1999 stock assessment, cowcod were formally declared overfished by the National Marine Fisheries Service in 2000. A rebuilding plan has been adopted to provide assurance that abundance will be restored to 40 percent of the unfished stock size in a minimal length of time. However, due to the unproductive nature of the stock, it is likely that rebuilding will require many decades (Leet et al. 2001).

Chilipepper (*Sebastes goodei*)

Chilipepper range from Queen Charlotte Sound, British Columbia to Magdalena Bay, Baja California (Leet et al. 2001). Adults are found on deep rocky reefs, as well as on sand and mud bottoms, from 150 to 1,400 feet; juveniles school and are frequently found in shallow nearshore waters, particularly in kelp beds (Leet et al. 2001). About 50 percent of female chilipepper are sexually mature at four years when they are between 11 and 12 inches, while males mature at two years and between eight and nine inches (Leet et al. 2001).

In the late 1800s, chilipepper and most other rockfish were caught by Portuguese longline fishermen who fished Monterey Bay from small two or three-person vessels (Leet et al. 2001). Longlines provided most, if not all, rockfish landings until the mid-1940s. Improvements in otter trawl technology subsequently led to trawl gear replacing longlines as the primary gear used to catch rockfish. Trawl gear enabled fishermen to make much larger landings with larger vessels. Trawlers have since accounted for the great majority of chilipepper landings, followed by set gill net and hook and line gears. During the 1990s, gill net landings have declined to very low levels, whereas hook-and-line gears have comprised a relatively higher portion of the catch (Leet et al. 2001).

Historically, chilipepper was not considered an important component of the party boat angler's catch in central and northern California due to its deep offshore distribution. In the early 1980s, Monterey and Santa Cruz party boat skippers began fishing chilipepper schools in the vicinity of the Monterey underwater canyon in late spring through summer (Leet et al. 2001). In contrast, southern California chilipepper partyboat landings peak during the winter months. Chilipepper was ranked third among rockfishes taken off central and northern California in 1989-1990, but its relative importance in the recreational fishery has dwindled throughout the 1990s. Since 1995, sport landings have comprised less than two percent of the total chilipepper catch (Leet et al. 2001).

The last stock assessment of chilipepper, conducted in 1998, indicated that unlike most other rockfish populations, the stock was in quite good condition. At that time, the population size was determined to be 35,000 tons, which is about 50 percent of the unexploited level. The healthy status of the chilipepper stock has been due to a very strong 1984 year-class that supported the fishery throughout the 1990s, although recent recruitments have been lower and the stock is slowly but steadily declining. Based on the assessment, the Pacific Fishery Management Council set the acceptable biological catch at 4,100 tons, although the Council lowered the total allowable catch (TAC) to 2,000 tons out of concern for bocaccio bycatch in chilipepper fisheries. Even with the lower TAC, the various fisheries have not been catching the quota (Leet et al. 2001).

Widow Rockfish (*Sebastes entomelas*)

Widow rockfish are found from Todos Santos Bay, Baja California, to Kodiak Island, Alaska. Peak abundance is off northern Oregon and southern Washington, with significant aggregations occurring south to central California (Leet et al. 2001). While many commercial catches occur at bottom depths between 450 and 750 feet, young fish occur near the surface in shallow waters, and adults have been caught over bottom depths to 1,200 feet (Leet et al. 2001). Widow rockfish often form midwater schools, usually at night, over bottom features such as ridges or large mounds near the shelf break (Leet et al. 2001). The schooling behavior of widow rockfish is quite dynamic and probably related to feeding and oceanographic conditions. At first, growth is fairly rapid and by age five widow rockfish average 13.5 inches. By age 15, growth slows greatly, when the average size is about 19 inches for females and 17.5 inches for males. Widow rockfish do not become reproductive until years after birth. For example, only 50 percent are mature by age five, but almost all are mature by age eight when they are 16.5 inches long (Leet et al. 2001).

During the 1970s, there were occasional reports of large trawl catches of “brownies” made incidental to the harvest of other rockfish, but commercial landings were small until markets improved in 1979 and the midwater trawl fishery exploded (Leet et al. 2001). At that time, fishermen began targeting widow rockfish and annual California landings exceeded 10,000 tons by 1982. Since 1983, however, strict regulations have limited the commercial harvest and recent landings in California have been in the vicinity of 1,000 tons (Leet et al. 2001). By 1982, it became obvious that the population was being rapidly depleted and would soon be overfished, if catches were not restricted. The fishery was placed under stringent regulations in 1983. Even so, the stock was recently declared overfished by the PFMC because spawning potential was reduced to below 25 percent of the unfished condition. In response, a rebuilding plan for the stock will be implemented in 2002 that will reduce catches to less than 1,000 tons per year. With a harvest rate of less than three percent the stock should rebuild in about 35 to 40 years to the productive fishery it once was, with yields in excess of 3,000 tons per year (Leet et al. 2001).

Bank Rockfish (*Sebastes rufus*)

Bank rockfish are found from Queen Charlotte Sound, British Columbia to central Baja California and Isla Guadalupe (off central Baja California). They are abundant from the southern Oregon-northern California area to at least southern California (Leet et al. 2001). They live in depths between 100 and 1,500 feet, but most commonly between 300 and 800 feet (Leet et al. 2001). Juveniles and sub-adults tend to be found in shallower waters than adults are. Demersal juveniles and adults often are found over high relief boulder fields or steep cliff faces with plenty of crevices and caves. They also are found over cobblestones or on mixed mud-rock bottoms, where they shelter near or beneath the hard substrate. Small numbers have been observed around the bottom of deeper offshore oil platforms (Leet et al. 2001). Males reach maximum length at a slightly faster rate than females and mature at a smaller size than females. A few males are mature at 11 inches and 10 years, and all are mature at 14.8 inches and 20 years (Leet et al. 2001).

Until the 1980s, bank rockfish were a relatively minor part of the commercial catch. However, as fishing effort off California expanded into deeper waters, landings of this species sharply increased. From 1981 to 1992, banks ranked among the top 10 rockfish species taken in California, averaging 1,115 tons annually, and ranked among the top three rockfish species landed at Monterey and Morro Bay. In general, catches after 1992, though variable, have remained somewhat steady. In 1998, about 450,000 pounds of bank rockfish were caught in the California commercial fishery. While bank rockfish are rarely caught in the recreational fishery north of Pt. Conception, California, they are a frequent catch of recreational anglers in deep waters off southern California (Leet et al. 2001).

In 2000, a partial stock assessment was made on bank rockfish. This assessment implied that there has been a substantial decrease in the bank rockfish population, particularly in the 1990s (Leet et al. 2001).

Dover Sole (*Microstomus pacificus*)

Dover sole occur from the Bering Sea to northern Baja California on mud bottoms at depths from 180 to 4,800 feet (Leet et al. 2001). Growth is rapid during the early years of life but decreases with age. Five-year-old Dover sole grow 0.7 inch per year, but by 10 years of age, growth slows to 0.4 inch annually. Dover sole may attain an age of over 50 years and reach 30 inches in length. Fifty percent of Dover sole females 12 inches long are mature. The youngest mature Dover sole in 1987-1988 studies was six years old, whereas earlier studies reported mature five-year-old females (Leet et al. 2001).

The directed Dover sole fishery began in 1943 when 28 tons were landed. Between 1944 and 1947, landings ranged from 62 tons to 1,400 tons. The fishery expanded to 3,600 tonsin 1948, at which time Dover sole landing records were separated from nominal or unspecified sole landings, and rose further to 5,850 tons by 1952. Annual landings then remained stable at approximately 4,000 tons until 1969. From 1969 through 1989, landings averaged 10,200 tons and from 1990 through 1999, average landings dropped to 5,892 tons (Leet et al. 2001).

Sport utilization of Dover sole is practically nonexistent. The depth distribution of Dover sole normally places them beyond most sport fishing activity, and Dover sole, because of their feeding habits, are not vulnerable to hook-and-line fishing.

In 1987 and 1988, NMFS conducted two surveys to assess the adult biomass of Dover sole in the area from Point Conception to Monterey Bay. The surveys found that 98 percent of the spawning biomass of Dover sole in central California waters live on the continental slope between 2,100 and 3,300 feet deep, an area characterized by low oxygen concentrations and very cold temperatures. A 1991 assessment using 1990 NMFS bottom trawl survey data provided estimates of biomass and yields for the area from Cape Mendocino, California to Cape Blanco, Oregon (Eureka area). Another assessment, conducted in 1992, included the Eureka area and the Columbia area and another completed in 1995 included the northern Monterey area as well as the US Vancouver area. The last Dover assessment, conducted in 1997, treated the entire population in the Monterey area through the Vancouver area as a single stock based on research on the genetic structure of the population. The Point Conception area population has yet to be fully assessed. Using yield recommendations presented in the 1997 assessment, the PFMC set a coastwide landed catch limit of 8,955 tons. This stock is believed to be in equilibrium and near the target biomass level that would provide maximum sustainable yield (Leet et al. 2001).

English Sole (*Pleuronectes vetulus*)

English sole range from San Cristobal Bay, Baja California to northwest Alaska in water as deep as 1,800 feet (Leet et al. 2001). Fish tend to move to deeper water in the winter and shallower water in the summer. Three-year-old female English sole, on average, are only about eight inches, while 10-year-old females are about 14 inches. Fifty percent of female English sole are usually mature at five years and nine inches (Leet et al. 2001).

English sole was the leading flatfish in that group until Dover sole took first place in 1949. Since then, English sole has been second in pounds landed except for 1970 through 1972, when petrale sole was second. The peak year for English sole was 1929, when 8.7 million pounds were caught off central California and at new fishing areas off Fort Bragg and Eureka. Annual landings in California averaged 2.8 million pounds during the 10 years from 1980 to 1989 and dropped to an average 1.3 million pounds between 1990 and 1999. The majority of recent California landings were made by trawlers fishing on the grounds off Eureka and San Francisco. Little is taken commercially south of Point Conception. Due to its depth the English sole is not targeted by recreational anglers (Leet et al. 2001).

Little information is available to estimate the status of the English sole stock in California. Catch-per-unit-effort data exist but are complicated by the multiple species aspect of trawl fishing. In 1993, an assessment using data collected from 1977 through 1992, was conducted for the English sole stocks off Oregon and Washington. Results indicate that the biomass increased steadily during the assessment period, which was attributed to high recruitment (Leet et al. 2001).

Sablefish (*Anoplopoma fimbria*)

The geographic distribution of sablefish extends from the Asiatic coast of the Bering Sea to northern Baja California (Leet et al. 2001). Adult sablefish are found from less than 300 to more than 4,800 feet deep, but peak abundance off California is at about 1,200 to 1,800 feet (Leet et al. 2001). Approximately 50 percent of female sablefish reach maturity at 23.6 inches long and six years of age off California. Females grow faster than males from age two and attain a larger maximum size. Sablefish may attain an age of over 50 years and reach a size of 47 inches and 126 pounds but are usually less than 30 inches and 25 pounds (Leet et al. 2001).

Prior to 1935, landings averaged about 500 tons annually. By 1935, annual landings had risen to 1,400 tons at a time when sablefish livers, because of their high vitamin A content, commanded a higher price than the edible parts of the fish. Landings increased to over 3,000 tons in 1945 due to strong wartime market demand, then varied from approximately 770 to 2,200 tons per year until 1972 (Leet et al. 2001). More intensive targeting of sablefish began in 1972 with the development and widespread use of sablefish traps, which proved highly effective. Foreign fishing fleets from the U.S.S.R, Japan, and the Republic of Korea fished for sablefish off California from 1967 to 1979, catching relatively minor quantities in most years. However, in 1976 the Republic of Korea reported a catch of 9,500 tons off California. The establishment of the U.S. 200-mile fishery conservation zone in 1977 phased out foreign fishing in those waters; consequently Japan, the principal foreign market for sablefish, became increasingly reliant on imports of U.S.-caught sablefish. Japanese demand for sablefish helped drive California landings to a record high of 14,287 tons in 1979, followed by a market collapse the next year to just 5,141 tons (Leet et al. 2001).

The first commercial sablefish landing limits were imposed coastwide in 1982 by the PFMC. Prior to that time, market demand, not resource availability or quotas, was the dominant force controlling statewide sablefish landings. From 1982 to 1989, regulations constrained statewide sablefish landings to an average of approximately 6,175 tons. Annual coastwide landing quotas remained at 19,183 tons from 1982 to 1984, then gradually declined to 9,800 tons in 1990 as the stock was fished down to the recommended long-term target level. Between 1990 and 2000, the Allowable Biological Catch (ABC) was reduced slightly to 10,661 tons.

Sport utilization of sablefish is negligible, with rare instances of large catches when schools of small sablefish concentrate around public piers. The depth distribution of sablefish normally places them beyond most sport fishing activity (Leet et al. 2001).

Fisheries-independent and dependent studies have had conflicting results. Stock assessments have been hampered by the lack of reliable age data. In 1998, two independent stock assessments were performed which resulted in biomass estimates ranging between 33,000 and 319,000 tons. Given the highly uncertain status of the population, it is unclear whether management has been too liberal or too conservative (Leet et al. 2001).

Coastal Pelagic Species (CPS)

Pacific Sardine (*Sardinops sajax*)

Historically, the northern subpopulation of Pacific sardines made extensive migrations, moving north as far as British Columbia in the summer months and returning south to southern California and northern Baja California in the fall. At present, the population is currently expanding, found primarily off central and southern California and Baja California, but extends as far north as Vancouver, British Columbia (Leet et al. 2001). Contraction and expansion of range and spawning area has been associated with changes in sardine population size around the world. Pacific sardines reach about 16 inches and live as long as 13 years but are usually less than 12 inches and eight years old. Most sardines in the historical and recent commercial catch were five years and younger. There is a good deal of regional variation in growth rate, with average size attained at a given age increasing from south to north (Leet et al. 2001).

A sustained fishery for Pacific sardines (Sardinops sagax) first developed in response to the demand for food during World War I. Demand grew, and fishing effort and landings increased from 1916 to 1936, when the catch peaked at over 700,000 tons (Leet et al. 2001). Pacific sardine supported the largest fishery in the Western Hemisphere during the 1930s and 1940s, with landings occurring in British Columbia, Washington, Oregon, and California. The fishery collapsed beginning in the late 1940s and declined, with short-term reversals, to less than 1,000 tons-per-year in the late 1960s (Leet et al. 2001). There was a southward shift in the catch as the fishery decreased, with landings ceasing in the northwest in the 1947-1948 season and in San Francisco in 1951-1952. Through the 1945-1946 season, most California landings were at Monterey and San Francisco, but San Pedro accounted for most subsequent landings (Leet et al. 2001).

Landings of sardines in Mexico began to increase from an annual average of 1,600 tons during the 1980s, to an average of nearly 42,000 tons per year through the 1990s. The total and average annual harvests by Mexico exceeded those for California over the period 1980 through 1999 (Leet et al. 2001). Though not targeted by the recreational fishery, Pacific Sardines are used for bait when available.

Spawning biomass of the Pacific sardine averaged 3,881,000 tons from 1932 to 1934, and fluctuated from 3,136,000 to 1,324,000 tons from 1935 to 1944 (Leet et al. 2001). The population then declined steeply over the next two decades, with some short reversals following periods of particularly successful recruitment, to less than 100,000 tons in the early 1960s. During the 1970s, spawning biomass levels were thought to be as low as 5,000 tons. Since the early 1980s, the sardine population has increased, and the total age one-plus biomass was estimated to be greater than 1.7 million tons in 1998 and 1999 (Leet et al. 2001).

<u>Northern Anchovy</u> (*Engraulis mordax*)

Northern anchovy are distributed from the Queen Charlotte Islands, British Columbia to Magdalena Bay, Baja California (Leet et al. 2001). The population is divided into northern, central, and southern subpopulations or stocks. The central subpopulation ranges from approximately San Francisco, California to Punta Baja, Baja California, with the bulk being located in the Southern California Bight (Leet et al. 2001). As juveniles in nearshore areas, anchovies are vulnerable to a variety of predators, including birds and some recreationally and commercially important species of fish. As adults offshore, anchovies are fed upon by numerous marine fishes (some of which have recreational and commercial value), mammals, and birds, including the State and federally listed California brown pelican. A link between brown pelican breeding success and anchovy abundance has been documented (Leet et al. 2001). Anchovy are all sexually mature at age two. The fraction of one-year-olds that is sexually mature in a given year depends on water temperature and has been observed to range from 47 to 100 percent (Leet et al. 2001).

Reliable records of California commercial landings of northern anchovy date from 1916. Landings were small until the scarcity of Pacific sardines caused processors to begin canning anchovies in quantity during 1947, when landings increased to 9,464 tons in 1947 from 960 tons in 1946 (Leet et al. 2001). To limit the quantity of anchovies being reduced to fishmeal, the California Fish and Game Commission required each processor to can a large proportion of the harvest (40-60 percent depending on can size). Anchovy landings declined with the temporary resurgence of sardine landings around 1951. Following the collapse of the sardine fishery in 1952, anchovy landings increased to nearly 43,000 tons in 1953, but subsequently declined due to low consumer demand for canned anchovy and increased sardine landings (Leet et al. 2001). Landings remained low through 1964.

During the early years (1916 through 1964), anchovy were harvested almost exclusively by California fishermen. Mexico did not begin harvesting anchovy until 1962. Beginning in 1965, the California Fish and Game Commission managed anchovy on the basis of a reduction quota. This quota had been taken by a fleet of approximately 40 small purse seine vessels operating off southern California known collectively as the “wetfish” fleet, which fishes for other species in addition to anchovy. In 1965, only 171 tons of anchovy were landed for reduction, which increased to an average of over 64,000 tons per year between 1965 and 1982 (Leet et al. 2001). After 1982, reduction landings decreased dramatically to an average of only 923 tons per year from 1983 to 1991, and fell to zero in

1992 through 1994. During the period 1995 to 1999, only four tons were reported as reduction landings (Leet et al. 2001).

Live bait boats fish for a variety of species, but anchovies comprised approximately 85 percent of the catch prior to 1991 (Leet et al. 2001). Pacific sardines became available to the live bait fishery again in 1992, and the composition of live bait catches shifted from primarily anchovy to primarily sardine. From 1996 through 1999, sardines constituted approximately 72 percent of the live bait catch (Leet et al. 2001). Historically, the anchovy live bait catch ranged from 4,000 to 8,000 tons per year and averaged approximately 4,500 tons annually between 1974 and 1991. This average dropped to slightly over 2,500 tons between 1992 and 1994 (Leet et al. 2001). Non-reduction (other than for live bait) landings averaged slightly over 2,200 tons per year from 1965 to 1994, and increased to an average of about 4,122 tons per year between 1995 and 1999 (Leet et al. 2001).

Estimates of the biomass of northern anchovy in the central subpopulation averaged 359,000 tons from 1963 through 1972, increased rapidly to over 1.7 million tons in 1974 and then declined to 359,000 tons in 1978 (Leet et al. 2001). Since 1978, biomass levels have tended to decline slowly, falling to an average of 289,000 tons from 1986 through 1994. Anchovy biomass during 1994 was estimated to be 432,000 tons (Leet et al. 2001). The size of the anchovy resource is now being determined mostly by natural influences, such as ocean temperature.

Pacific Mackerel (*Scomber japonicus*)

Pacific mackerel occur worldwide in temperate and subtropical coastal waters. In the eastern Pacific, they range from Chile to the Gulf of Alaska, including the Gulf of California. They are common from Monterey Bay, California to Cape San Lucas, Baja California, but are most abundant south of Point Conception, California (Leet et al. 2001). Pacific mackerel usually occur within 20 miles of shore, but have been taken as far offshore as 250 miles. Pacific mackerel are typically found near shallow banks, and juveniles are commonly found off sandy beaches, around kelp beds, and in open bays. The largest recorded Pacific mackerel was 24.8 inches and weighed 6.4 pounds, although commercially harvested Pacific mackerel seldom exceed 16 inches and two pounds. Growth is believed to be density-dependent, as fish reach much higher weights-at-age when the population size is small (Leet et al. 2001).

Pacific mackerel supported one of California's major fisheries during the 1930s and 1940s and again in the 1980s. The canning of Pacific mackerel began in the late 1920s and increased as greater processing capacities and more marketable packs were developed. Landings decreased in the early 1930s, due to the economic depression and a decline in demand, and then rose to a peak of 73,214 tons in 1935 (Leet et al. 2001). During this period, Pacific mackerel was second only to Pacific sardine in annual landings. The mackerel fishery then experienced a long, fluctuating decline. A moratorium was placed on the fishery in 1970 after the stock had collapsed (Leet et al. 2001).

In 1972, legislation was enacted which imposed a landing quota based on the age one-plus biomass. A series of successful year classes in the late 1970s initiated a recovery, and the fishery was reopened under a quota system in 1977. During the recovery period from 1977 to 1985, various adjustments were made to quotas for directed take of Pacific mackerel and to incidental catch limits. These measures were intended to lessen the impact of the recovering population on the jack mackerel fishery, and to accommodate the development of the Pacific mackerel fishery as the population increased. From 1990 through 1999, Pacific mackerel accounted for 87 percent of total mackerel landings in California. Pacific mackerel ranked third in volume of California finfish landings throughout the 1990s (Leet et al. 2001).

Pacific mackerel have ranked among the top 11 most important sportfish caught in southern California waters, primarily because they are abundant rather than desirable (Leet et al. 2001). The recreational catch of Pacific mackerel averaged 1,500 tons per year from 1977 through 1991, and 700 tons per year from 1993 through 1999 (Leet et al. 2001). During the commercial fishing moratorium, the sport fishery became the largest user of Pacific mackerel in California. The recreational catch increased during the late 1970s and early 1980s, with more than one million fish per year caught from 1979 through 1981. Recent estimates of annual recreational catches indicate a steady decline since 1981 to about 200 tons of Pacific mackerel in southern California in 1999 (Leet et al. 2001). The catches from commercial passenger fishing vessels (CPFVs) have declined from a peak in 1980 of over 1.31 million Pacific mackerel, and an average of over 700,000 fish per year during the 1980s, to an average of slightly over 330,000 fish per year through the 1990s. The reported CPFV catch in 1998 totaled only 136,614 fish (Leet et al. 2001).

Historical estimates of Pacific mackerel biomass along the Pacific Coast indicate a decline in total biomass from 1932 until 1952. After a brief resurgence, the population reached a peak in 1962, then declined to less than 10,000 tons by 1966, and remained low until the late 1970s (Leet et al. 2001). A series of successful year classes beginning in 1976 brought about a resurgence, and the age one-plus biomass peaked in 1982, at over one million tons. Since then, it has precipitously declined. Recent stock assessments indicate that biomass in the late 1990s was approximately 120,000 tons (Leet et al. 2001). Information derived from deposits of Pacific mackerel scales on the sea floor indicates that the prolonged period of high biomass during the late 1970s and 1980s was an unusual event that might be expected to occur about once every 60 years (Leet et al. 2001). It is estimated that the maximum long-term yield of Pacific mackerel might be 29,000 to 32,000 tons under management systems similar to that in current use. It is difficult to assess the effects on the catch of recent warm temperatures, possible changes in availability of young fish, and the deteriorating markets. However, it is unlikely that the recent high harvest levels can be sustained (Leet et al. 2001).

<u>Jack Mackerel</u> (*Trachurus symmetricus*)

Jack mackerel are actually members of the jack family, Carangidae, and are not true mackerel. They are widely distributed throughout the northeastern Pacific Ocean, where young fish (up to six years and 12 inches fork length) are found schooling over shallow rocky reefs, generally less than 200 feet deep, and along rocky shorelines of the coast and islands off southern California and Baja California (Leet et al. 2001). Large fish (16 years and older and 20 inches fork length) are found offshore and farther north, east of a line that goes from Cabo San Lucas to the eastern Aleutian Islands, and includes the Gulf of Alaska. Most (70 percent) female jack mackerel from the southern California fishery become mature around their first birthday. By their second birthday, 90 percent of the females are spawning (Leet et al. 2001).

Much of the catch between 1926 and 1946 was taken incidentally with sardine and Pacific mackerel and was sold at fresh fish markets where it did not spoil as quickly as Pacific mackerel. Landings were low, varying between 200 and 15,000 tons annually and comprising less than three percent of the CPS landings each year (Leet et al. 2001). In 1947, jack mackerel landings increased almost tenfold to 65,000 tons as the canning industry turned to jack mackerel in the face of the collapsing sardine fishery. Between 1947 and 1979, jack mackerel landings ranged from 800 to 73,000 tons, comprising six percent to 65 percent of the annual CPS landings (Leet et al. 2001).

The recovery of the Pacific mackerel population in the late 1970s shifted effort away from jack mackerel. The CPS fleet prefers Pacific mackerel, because jack mackerel occur farther from port and tend to aggregate over rocky bottom where there is increased chance of damage to the encircling nets. The recovery of the Pacific sardine and increased demand for squid worldwide have also contributed to the decline in jack mackerel landings in California. Since 1991, jack mackerel has been caught primarily from December through April, with landings low during the remainder of the year. Landings have averaged less than 2,000 tons each year, comprising only two percent of the CPS landings. Most of the catch occurs in southern California (Leet et al. 2001).

Large jack mackerel have occasionally contributed to the CPFV fishery. In 1953, a run of large fish was encountered in southern California, which contributed 13 percent of the CPFV catch in southern California and 8.6 percent statewide (Leet et al. 2001). That was an exceptional year and, since then, jack mackerel have been of minor importance in the CPFV catch. Smaller jack mackerel are caught at times from fishing piers in southern and central California. Since 1980, recreational landings have been highly variable, ranging from an estimated 5,000 fish to over 350,000, based on MRFSS data. Live bait landings of jack mackerel in the 1990s have been negligible due to a preference for Pacific sardine and northern anchovy as bait by sport anglers (Leet et al. 2001).

The most recent estimate of total biomass was made in 1983. Total biomass was estimated at 1.63 to 1.99 million tons with spawning biomass accounting for 1.50 million tons. These estimates must be viewed as tentative approximations of the population because of two factors. First, at the time, the spawning frequency of jack mackerel was not known, and estimates were based on the spawning frequencies of northern anchovy (15 percent of females spawn each day during the peak spawning months) which has similar gonad morphology and a protracted spawning season like jack mackerel. Second, estimates were derived from plankton surveys for eggs and larvae in the Southern California Bight, which did not cover the entire range of the spawning population, and assumptions were made for the contribution of older jack mackerel outside the survey area (Leet et al. 2001). A recent study estimated the spawning frequency for jack mackerel at 20 percent of the spawning population. Using a spawning frequency of 20 percent would have yielded a lower biomass estimate in 1983. Although we now have an estimate of spawning frequency, no other biomass estimates have been produced since 1983 (Leet et al. 2001).

Highly Migratory Species

Regional upwelling carries nutrient-rich waters from canyons and island shelf areas to the photic zone resulting in increased primary productivity and larger zooplankton populations, which support exceptionally abundant populations of small schooling species such as the northern anchovy, Pacific saury (*Cololabis saira*), Pacific sardine, and Pacific and jack mackerel. These fish are in turn preyed upon by larger pelagic fish, and together they form a significant contribution to the forage base of marine mammals and birds. Schooling species found in offshore waters include northern anchovy, Pacific sardine, yellowfin tuna (*Thunnus albacares*), bluefin tuna (*T. thynnus*), albacore (*T. alalunga*), Pacific bonito and salmon (*Oncorhynchus spp*.). Northern anchovy and Pacific sardine are among the most abundant species and are the major prey of the mackerel and bonito; northern anchovy, Pacific sardine, mackerel, and bonito form the food base for the tuna.

The largest habitat in the SCB is the pelagic (open water) zone. Forty percent of the fish species in the SCB occupy this habitat, which has three vertical subzones (epipelagic, mesopelagic, and bathypelagic). The epipelagic zone is dominated by small, schooling fish such as northern anchovy, Pacific sardine and Pacific mackerel, that feed on plankton; by predatory schooling fish such as Pacific bonito and yellowtail; and by large, solitary predators like blue shark (*Prionace glauca*) and swordfish (*Xiphias gladius*) (Mais 1974, 1977; Squire 1983, Bedford and Hagerman 1983; Cailliet and Bedford 1983). Northern anchovy and Pacific Sardine are the most abundant epipelagic fish and may be the usually dominant species (MacCall et al. 1976; Squire 1983). However, abundance of epipelagic fishes varies with the seasons. Anchovy schools are more abundant and larger in the inshore areas of the northern SCB during the summer and fall (Cross and Allen 1993). From late winter to spring, anchovy schools move offshore to spawn (Mais 1974, 1977). Yellowtail migrate into the SCB from Baja California in the spring when surface water temperatures begin to warm. They spawn offshore in the summer and return south in the fall (Cross and Allen 1993).

The pelagic zone plays a critical role in sustaining fish populations because the eggs of nearly all fish are either deposited or hatched there. Even the larvae of fish that bear live young or attach eggs to the substrate (Cross and Allen 1993) spend the initial portion of their lives in the pelagic zone. Microscopic fish larvae are known as ichthyoplankton. The abundance of ichthyoplankton is greatest in the SCB and off northern Baja California (Cross and Allen 1993). The ichthyoplankton population of the SCB within 62 miles (100 kilometers) from the coast is dominated by northern anchovy larvae (83 percent). Rockfish (*Sebastes spp*.) and California smoothtongue (*Leuroglossus stilbius*) larvae each represent 4 percent of the ichthyoplankton population. Larvae of other species, such as white croaker, pacific hake, and California halibut form 2 percent or less of ichthyoplankton in the SCB (Gruber et al. 1982). Research on ichthyoplankton dynamics in the SCB has focused primarily on Pacific sardine, northern anchovy, and Pacific mackerel (Hunter 1981; Sherman et al. 1983).

<u>Albacore</u> (*Thunnus alalunga*)

Albacore are widely distributed throughout the world's oceans in tropical, sub-tropical, and temperate zones. The North Pacific albacore stock, the population targeted by both the commercial and recreational fisheries of California, is centered around 35° N latitude in the Pacific Ocean. This stock's distribution extends from the central (west) coast of Mexico to the Gulf of Alaska in the eastern Pacific Ocean, and from the equator to the north (east) coast of Japan in the western Pacific Ocean (Leet et al. 2001). The actual boundaries of the stock's range depend largely on the season of the year and oceanic conditions. Approximate growth rates for North Pacific albacore are as follows: age-one fish are 14.2 inches and 2.2 pounds; age-two fish are 20.5 inches and 6.5 pounds; age-three fish are 25.6 inches and 12.7 pounds; age-four fish are 30 inches and 20.3 pounds; age-five fish are 33.5 inches and 28.3 pounds, and age 10-12 fish can reach up to 55.0 inches and over 100 pounds (Leet et al. 2001). Albacore are believed to reach a maximum age of roughly 11-12 years, although interpretations of age for older fish are typically subject to increased uncertainty and thus, longevity cannot be strictly defined at this time (Leet et al. 2001).

The commercial fisheries for albacore developed rapidly following the first canning operations of this species in 1903 in San Pedro Bay, California. The commercial fisheries for albacore continued to expand through the mid-1940s, extending northward to coastal waters off northern California, Oregon, and Washington, and westward to the central Pacific Ocean, several hundred miles off the California coast (Leet et al. 2001). The geographic expansion of the fisheries slowed during the 1950s through the mid-1960s, but the flourishing market continued, with record landings during this period that averaged roughly 30 million pounds annually. During the mid-1970s, the commercial fishing fleet extended farther into the central Pacific Ocean, with some vessels fishing north and west of the Hawaiian Islands, as far as the International Date Line. Since the 1980s, the albacore fisheries of California have typically operated within roughly 900 miles of the U.S. Pacific coast; the distance largely dependent on the stock's migratory route in any given year (Leet et al. 2001). California's commercial fishery for albacore has generally concentrated on the North Pacific albacore stock during the summer and fall seasons as the fish move through waters of the northeastern Pacific Ocean during their annual migration. However, in recent years during the winter months, some vessels have also targeted the South Pacific albacore stock that inhabits waters off New Zealand's east coast between the International Date Line and 110° W longitude. Commercial landings of albacore in California have varied over the last decade, ranging from a high of 12.3 million pounds in 1999 to a low of 1.8 million pounds in 1995 (Leet et al. 2001).

Recreational fishing for albacore developed during the early 1900s, when vessel owners in southern California first realized that the angling community was very willing to charter their boats for fishing. As the popularity of albacore increased, as a food and sport fish, so did the CPFV industry. In the very early years of the sport fishery, only a few CPFV trips were made, concentrating in waters around the Channel Islands; however, by the mid 1950s, more than 100 CPFVs carried anglers to other inshore waters in pursuit of the stock as it conducted its annual migration (Leet et al. 2001). The CPFV industry continued to grow during the 1960s, with increases in fishing capacity and range, which allowed boats to carry more anglers and venture further from port in years when the albacore remained farther offshore. Over the last 10 years, from 40 to 60 large CPFVs, that typically accommodate from 15 to 60 anglers for one-to three-day trips, have fished for albacore in California waters, mostly based in southern California, with several operations further north in Morro Bay and San Francisco (Leet et al. 2001). Additionally, from 60 to 90 smaller CPFVs have routinely operated in California since the early 1990s, with these vessels usually carrying six to 10 anglers on one-day fishing excursions. Catches of albacore on CPFV trips have been highly variable over the years, based largely on the migratory behavior of the stock in any given year. For example, in 1994, as the stock approached the coast of North America, the bulk of the population traveled north to waters off Oregon and Washington, resulting in a poor fishing season for recreational anglers in California, where less than 200 albacore were landed on CPFV related trips (Leet et al. 2001). In 1999, the stock took a more southerly route as it neared the U.S. Pacific Coast and spent much of the summer and fall in inshore waters off southern California and northern Mexico, where anglers on CPFVs landed a total of 258,448 fish – the highest total on record (Leet et al. 2001).

Fishery researchers generally agree that the North Pacific albacore population is currently a relatively healthy stock that has responded favorably to rates of exploitation over the last decade or so. Recent assessments of the entire stock indicated that sustainable yields, on a global basis, likely range between 176.4 and 220.5 million pounds, roughly the level of total annual catch observed during the latter part of the 1990s (Leet et al. 2001). For example, the combined commercial and recreational landings in 1999 (U.S. and foreign) was approximately 209.5 million pounds. Catches and fishing effort associated with U.S. fisheries for albacore, both commercial and recreational, were considerably higher in the latter part of the 1990s than during the early and mid 1990s, which is baseline information that generally indicates the population has responded relatively well to recent levels of use (Leet et al. 2001).

<u>Swordfish</u> (*Xiphias gladius*)

Swordfish are found in all tropical, subtropical, and temperate waters, sometimes entering sub-temperate water as well. In the western Pacific, it ranges from 50º N to 45º S whereas in the eastern Pacific, from 50º N to 35º S (Leet et al. 2001). Swordfish tend to concentrate where major ocean currents meet, and along temperature fronts. They are epi- and meso-pelagic, inhabiting the mixed surface waters where temperatures are greater than 55º F but also can move into water as cool as 41º F for short periods aided by specially adapted brain and eye heat exchange organs (Leet et al. 2001).

The California harpoon fishery dates back to the early 1900s and the Tuna Club of Avalon reported the first record of a recreationally caught swordfish in 1909 that weighed 339 pounds (Leet et al. 2001). In 1931, the State Legislature required commercial fishing licenses and allowed only harpoons for the commercial take of swordfish. Recreational anglers were allowed to harpoon swordfish until 1935. Participation in the harpoon fishery peaked in 1978 with 309 vessels landing 2.6 million pounds before being largely displaced by the more efficient drift net fishery (Leet et al. 2001). Annual landings of drift net caught swordfish increased rapidly peaking in 1984 at 5.2 million pounds. Regulations enacted in 1985 were designed to reduce fishing effort and landings, limit the number of permits to 150, restrict the season of operation and provide for several time-area closures aimed at reducing bycatch and interactions with recreational anglers. Drift net vessels, which numbered 220 in 1985, have decreased due to those regulations and now number about 120 vessels, of which only about 100 are fully active (Leet et al. 2001). This fishery is now in a period of steady production with annual yields of 2.6 million pounds

The condition of the swordfish stocks in the Pacific Ocean is unclear. Results of assessment studies so far have a large margin of uncertainty, owing in part to uncertainty in the stock structure of the population. Recent genetic studies suggest swordfish off the western coast of the Americas mix with swordfish from the central and western North Pacific (Leet et al. 2001). This result tends to support the hypothesis of a single stock in the Pacific with an uneven distribution that results in areas of high and low abundance. Studies of catch rates, on the other hand, suggest three or more stocks as demonstrated by high catch rates persisting in distinct areas that are separated by areas of low to zero catch rates in between. Also, genetic studies in the western Pacific found significant differences between southern and northern swordfish, indicating little mixing (Leet et al. 2001). Stock assessment studies using both hypotheses have concluded that the stocks appear to be in good condition and with use at or below estimated MSY levels. These studies, however, have not included fishery statistics from recent years when some fisheries expanded significantly, nor have they taken into account the complex biology, such as sexual dimorphism and diurnal behavior, of swordfish indicating a need for more current stock assessment (Leet et al. 2001).

<u>Pacific Northern Bluefin Tuna</u> (*Thunnus orientalis*)

Spawning of Pacific northern bluefin occurs between Japan and the Philippines in April, May, and June, off southern Honshu in July, and in the Sea of Japan in August (Leet et al. 2001). The larvae, postlarvae, and juveniles produced south of Japan are carried northward by the Kuroshio Current toward Japan. Fish in their first year of life, about six to 24 inches in length, are caught in the vicinity of Japan during the summer, fall, and winter (Leet et al. 2001). The results of tagging experiments indicate that some of these remain in the western Pacific Ocean and others depart for the eastern Pacific during the fall or winter of their first year of life or the summer, fall, or winter of their second year of life. The journey from the western to the eastern Pacific takes as little as two months, or perhaps even less (Leet et al. 2001).

Most of the information regarding distribution of the catches of Pacific northern bluefin by tuna purse seiners has been obtained from the logbook records of these vessels. Bluefin are rarely encountered south of Cabo San Lucas, Baja California, or north of Point Conception, California. Within this area, a considerable change has taken place during the 20th century. Until 1930, fishing was conducted only off California. During that year, bluefin were discovered off Isla Guadalupe, Baja California, and about 40 percent of the catch was made in that area (Leet et al. 2001). From 1930 through 1947, fishing was conducted off California and Baja California, but in most years the majority of the catch came from off California. From 1948 to the present, however, most of the catch has been made off Baja California. The average annual catches made off California during the 1960s, 1970s, 1980s and 1990s have been considerably less than the average annual catches made in the same area from 1918 to 1929 (Leet et al. 2001).

F ishing for Pacific northern bluefin tuna began in California as a sport in 1898. Prior to World War I, many large fish were taken, particularly by vessels based at Santa Catalina Island. The largest of these fish weighed 251 pounds (Leet et al. 2001). More recently, the average size of the sport-caught fish has been roughly 50 pounds, although large fish are still taken. A large portion of the sport-caught fish is taken by fishermen who are directing their efforts primarily toward albacore (Leet et al. 2001).

The total annual catches of Pacific northern bluefin by commercial and sport vessels in the eastern Pacific Ocean, prior to 1918, were negligible. The data for 1918 through 1960 include only the catches landed in California, but it is believed that the catches landed elsewhere, prior to 1961, were inconsequential. The catches tended to be greater during the 1960s and 1970s than during the previous period, probably because of the conversion during 1959 and 1960 of most of the tuna bait boats to purse seiners, and the addition of many new purse seiners to the fleet (Leet et al. 2001). The catches of Pacific northern bluefin in the eastern Pacific have been less, on average, during the 1980s and 1990s than during the 1960s and 1970s (Leet et al. 2001). Catch data, length-frequency data, and data on fish tagged in the western Pacific and recaptured in the eastern Pacific suggest that this decline is due to a decrease in the availability of bluefin in the eastern Pacific (i.e., a decrease in the proportion of the population which has migrated to the eastern Pacific) and a decrease in the number of boats which direct their effort at bluefin (Leet et al. 2001).

Skipjack Tuna (*Katsuwonus pelamis*)

Skipjack tuna occur throughout the tropical, subtropical waters and warm temperate waters of all oceans. There are two stock structures hypothesized for Pacific skipjack tuna, a single stock with isolated subgroups or two or more different stocks. This description considers skipjack tuna in the eastern Pacific east of 150° W longitude (Leet et al. 2001). In the eastern Pacific, skipjack tuna are generally distributed between 40° N and 40° S latitude and between 150° W longitude and the coastlines of the U.S., Mexico, Central and South America. During El Niño events skipjack tuna may be found as far north as 50° N along the U.S. West Coast (Leet et al. 2001).

Commercial landings of skipjack tuna in California started in 1918, and mainly supplied canneries where skipjack tuna were processed as light meat tuna. Small quantities of skipjack tuna were also sold to local markets. Commercial landings of skipjack tuna in California increased from three million pounds in 1918 to 156 million pounds in 1954 (Leet et al. 2001). The landings fluctuated considerably then decreased to a low of 30 million pounds in 1973 before peaking again at its highest level (174 million pounds) in 1980 (Leet et al. 2001). Since 1976, skipjack tuna landings in California declined to average 10 million pounds from 1985 to 1999. The decline in commercial landings in California can be attributed to the relocation of cannery operations to American Samoa and Puerto Rico and the re-flagging of some vessels. Currently, only one cannery is operating in California.

California recreational fisheries for skipjack tuna typically operate in waters off southern California and Mexico. The duration of trips is usually one to seven days. The fleet consists mainly of CPFV and some private fishing vessels. Skipjack tuna landings from the CPFV fishery reached highs of 103,000 fish in 1983, and52,000 fish in 1990 (Leet et al. 2001). Since 1990, skipjack tuna recreational landings have generally decreased to 14,000 fish in 1998 (Leet et al. 2001).

In general, the population of skipjack tuna in the eastern Pacific is underutilized by fisheries operating in the area and is well above levels that are needed to produce maximum sustainable yield (MSY). The apparent abundance of skipjack tuna in the eastern Pacific is highly variable. This variability is apparently caused more by effects of environmental conditions than by the effects of the fishery. The simplest estimate of abundance can be obtained from trends in catches. Catches peaked at 186,800 tons in 1978, and decreased to 54,500 tons in 1985. During the period from 1986 to 1994, catches varied between 69,000 and 100,000 tons before increasing to 266,000 tons in 1999 (Leet et al. 2001).

Yellowfin Tuna (*Thunnus albacares*)

Yellowfin tuna in the eastern Pacific are distributed throughout areas between 400° N and 400° S latitude and between 1500° W longitude and the coastlines of the U.S., Mexico, Central, and South America. The eastern Pacific stock is generally considered a separate population that is not believed to interact appreciably with stocks in the central and western Pacific (Leet et al. 2001). Yellowfin tuna are typically found in sea surface temperatures between 650°F and 880°F and are usually confined to the upper 330 feet of the water column, or between the surface and the thermocline. Seasonal migrations are primarily along the coast. Surface schools of small yellowfin tuna in the eastern Pacific can be found aggregated around floating objects or in free-swimming unassociated schools, while larger yellowfin tuna are usually found in schools associated with dolphins (Leet et al. 2001).

California landings of commercially caught yellowfin tuna date back to 1919. These landings supplied canneries mainly in California, where yellowfin tuna were processed as light meat tuna. In recent years, some commercial, yellow fin tuna landings were also purchased by local markets and restaurants. Commercial landings of yellowfin tuna in California, while fluctuating, generally increased from 350,000 pounds in 1919 to 280 million pounds in 1976. Since 1976, yellowfin tuna landings declined steadily to three million pounds in 1999. Yellow fin tuna landings from the recreational CPFV fishery, reached a record high of 120,000 fish in 1983, decreased to 4,000 fish in 1985, and averaged 81,000 fish from 1995 to 1998 (Leet et al. 2001).

In general, the population of yellowfin tuna in the eastern Pacific is being fully utilized by fisheries operating in the area and is at levels that will produce the maximum sustainable yield (MSY). The Inter-American Tropical Tuna Commission (IATTC) has recommended an annual yellowfin tuna catch quota in the eastern Pacific since 1966 to maintain the stock at MSY. Catches peaked at 277,300 tons in 1976, decreased to 111,500 tons in 1983, peaked again in 1989 at 337,000 tons, and then decreased to 301,400 tons in 1997 (Leet et al. 2001). Because of management-imposed measures, it is difficult to use strictly catch as an indicator of overall population abundance. However, four abundance indices, one based on estimates of standardized catch-per-days fishing, two based on age models, and one based on a searching-time method, have been developed and indicate that abundance dropped steeply from the late 1960s to historically low levels in the early 1980s. Abundance estimates rebounded substantially in 1986 and since then have remained fairly constant at slightly lower levels than in 1986. Stock assessments for yellowfin tuna in the eastern Pacific are conducted annually by the IATTC. The latest assessment indicated that the eastern Pacific yellowfin tuna fishery could continue to harvest approximately 297,000 tons annually without further lowering the stock size. In accordance with these findings, the IATTC set the annual 1998 yellowfin quota at 231,000 tons, with 16,500 ton increments added at the discretion of the IATTC.

<u>Striped Marlin</u> (*Tetrapturus audax*)

Striped Marlin are widely distributed throughout most tropical, sub-tropical and temperate waters of the Pacific and Indian oceans but does not occur in the Atlantic except for occasional strays off western South Africa (Leet et al. 2001). Japanese longline data indicate a horseshoe-shaped distribution across the central North and South Pacific with a continuous distribution along the west coast of Central America. It is apparently more abundant in eastern and north central Pacific than elsewhere (Leet et al. 2001). Striped marlin mature between 55 and 63 inches eye-to-fork length (EFL) and reach a maximum size of nearly 12 feet and more than 450 pounds (Leet et al. 2001).

The California Legislature banned the use of harpoons to take striped marlin in 1935 and further curtailed the sale and import of striped marlin in 1937 thus preserving the southern California fishery entirely for recreational anglers. A 31-year-long angler survey indicates fairly low, but steady, catch rate averaging 0.10 fish per anger fishing day but ranging to 1.0 or greater during El Niño periods (Leet et al. 2001). The southern California catch of striped marlin taken by the commercial passenger fishing vessel (CPFV) fleet averages six striped marlin per year. The striped marlin catch rate is greatly improved off Baja where anglers average 0.3 to 0.65 striped marlin per day of fishing (Leet et al. 2001). Estimated recreational catches of striped marlin off Los Cabos, Baja California Sur, averaged 12,000 fish annually between 1992 and 1996, but only averaged 260 fish off

Mazatlan. The estimated incidental catch from the longline shark fishery in Mazatlan averaged 680 striped marlin over the same period (Leet et al. 2001).

The Pacific striped marlin resource appears healthy regardless of whether a single Pacific-wide stock or two separate north and southern stocks are assumed. The relationship between catch and fishing effort in the Japanese longline fisheries show sustained catches over a wide range of fishing intensities, suggesting Pacific-wide catches are below the estimated maximum sustainable yield of 53 million pounds (Leet et al. 2001). Catches are fairly stable at around 25 to 30 million pounds. Angler catch and effort surveys indicate CPUE off California and Mexico has changed little since 1985 (Leet et al. 2001).

<u>Shortfin Mako Shark</u> (*Isurus oxyrinchus*)

The shortfin mako shark is distributed in temperate and tropical seas worldwide. In the eastern Pacific, it is distributed from Chile to the Columbia River and can be found off the U.S. West Coast from southern California northward to Washington. However, it is most common off southern California and is seldom caught north of the Mendocino Escarpment (Leet et al. 2001). It is considered an oceanic species, occurring from the surface to at least 500 feet in depth, and is rarely found in areas where the water temperature falls below 61° F.

It took the application of an entirely different fishing gear to create commercial interest in the mako. During 1988, the California Fish and Game Commission established an experimental shark fishery for mako and blue sharks using drift longlines. This gear proved much more efficient than drift gillnets. By 1990, stringent regulations were implemented that included an annual quota, time-area closures, and a requirement to reduce the bycatch and waste of blue sharks by establishing a market. In 1992, the commission did not renew the longline permits and the experimental fishery ended (Leet et al. 2001). This was due to the inability of the fishermen to establish a market for the bycatch of blue sharks and a well organized opposition by the sport fishing industry to a directed commercial fishery for mako sharks. Currently, mako sharks are taken by drift gillnets and hook-and-line. Most mako sharks, however, are taken in the drift gillnet fishery for thresher sharks and swordfish. Annual landings have fluctuated from over 600,000 pounds in 1987 to less than 100,000 pounds in 1999 (Leet et al. 2001).

Makos have long been esteemed as prized game fish along the East Coast of the U.S. During the early 1980s, the mako captured the attention of the southern California sport fishing public. In the mid-to late-1980s, estimates of the number of California angler trips for sharks grew ten-fold from 41,000 to 410,000 annually. The principal target of these trips was the shortfin mako shark (Leet et al. 2001). After the increase during the 1980s, the sport fishery for mako sharks has stabilized at a relatively high level. Total annual landings (sport and commercial) peaked in 1987 at 464,308 pounds and again in 1994 at 394,792 pounds (Leet et al. 2001). In both cases, landings declined rapidly in the two years following the peaks. Currently, commercial passenger fishing vessels run fishing trips on a regular basis from nearly all ports in southern California.

The present status of the shortfin mako shark in State and Federal waters off California is not known but is of concern. Adult mako sharks do not frequent California's coastal waters; therefore, they are not subject to local fisheries. The real threat to the mako population off California and in the eastern Pacific lies in the potential for over-development of fisheries within the coastal nursery (Leet et al. 2001).

Thresher Shark (*Alopias vulpinus*)

The distribution of the common thresher shark is circumglobal. In the eastern Pacific, it occurs from Goose Bay, British Columbia south to off Baja California, and off Panama and Chile (Leet et al. 2001). Abundance in the Pacific Ocean is thought to decrease rapidly beyond 40 miles from the coast, although catches off California and Oregon do occur as far as 100 miles offshore and sometimes beyond. It is found in temperate and warm oceans penetrating into tropical waters, seeming to prefer areas characterized by high biological productivity, the presence of strong frontal zones separating regions of upwelling and adjacent waters, and strong horizontal and vertical mixing of surface and subsurface waters. Such habitats are conducive to production and maintenance of schooling pelagic prey upon which it feeds. Adults, juveniles, and post-partum pups occur within California waters (Leet et al. 2001). Two other species of thresher shark, the pelagic (A. pelagicus) and the bigeye thresher (A. superciliosus) also occur off California, but these species are much less common, averaging only about one and nine percent, respectively, of the total drift net thresher catch in the 1990s (Leet et al. 2001).

The common thresher shark is the leading commercial shark in California, although landings are much less than they were during the first decade of the drift gillnet fishery. In the early years, from 1977 through 1989, annual commercial landings averaged 1.1 million pounds dressed weight (dw) per year, ranging from 0.1 million pounds in 1977 to a peak of 2.3 million pounds in 1982 (Leet et al. 2001). More recently, catches from 1990 through 1998 have averaged about 0.4 million pounds with a low of 0.3 million in 1995 and a high of 0.8 million pounds in 1991, remaining at 0.4 million pounds over the past three years (Leet et al. 2001). Fish are taken primarily by drift gillnets (78 percent) followed by set gillnets (18 percent), and other assorted gears (4 percent). Currently, there are about eight shark fishing tournaments held annually in southern California. Party boat catches, which are thought to represent a relatively small portion of the total sport catch, have averaged about 55 fish per year, with a peak of 163 fish taken in the 1993 El Niño year.

There are indications that management actions taken after the mid 1980s and resulting reduction in fishing pressure may have contributed to a rebuilding in the stock over the last decade (Leet et al. 2001). In the early 1990s, some mid-sized fish were beginning to reappear in wholesale market samples in California. More recently, an increase in average size of fish and in catch-per-unit of effort has been noted in the thresher shark catch off Point Conception, an area that historically has had the most consistent and highest thresher catches. It is not known, however, to what extent environmental changes and shifts in distribution might influence these observations, since this area is but a small portion of the total coastal range of the species. The potential annual rate of population increase for the common thresher shark at the maximum sustainable yield population level has been estimated at four to seven percent per year (Leet et al. 2001).

Blue Shark (*Prionace glauca*)

The blue shark is an oceanic-epipelagic and fringe littoral species with a circumglobal distribution. It is found in all temperate and tropical oceans and is thought to be the most wide-ranging shark species (Leet et al. 2001). Although this species can be found in oceanic waters between 43° F and 82° F, it is most commonly found in cooler water temperatures between 45° F and 61° F (Leet et al. 2001). In tropical waters, blue sharks show submergence and are typically found at greater depths. In temperate waters, blue sharks are caught within the mixed layer and generally range between the surface and the top of the thermocline, but have been documented as deep as 2,145 feet (Leet et al. 2001). In the Pacific, blue sharks are most predominant between 35° N and 45° N (Leet et al. 2001).

Blue sharks are not a major target of California's recreational or commercial fisheries. Urea stored in their blood system quickly turns to ammonia when the shark dies, thus rendering the meat unpalatable. Development of a quality meat product has been the limiting factor in creating commercial interest. Only two serious attempts at developing a quality food product in California have occurred. The first took place in 1979 and 1980 when one vessel fished blue sharks experimentally with longline gear. Product quality was judged to be good enough to establish blue shark as a viable alternate fishery, and 150,000 pounds dressed meat were sold. Although market interest developed in several western states, a steady demand could not be assured and the fishery was discontinued (Leet et al. 2001).

The second attempt at developing a food product began in 1988 with an experimental longline fishery directed at shortfin mako and blue shark. Participants in the fishery were required to develop a market for human consumption with the bycatch of blue sharks, which were not released alive. In 1989 and 1990, a total of 54,000 pounds of blue shark was sold for making jerky and "fish and chips." It was clear from these attempts, however, that a quality food product and related market had not been achieved. Participants in the fishery substantially reduced the incidental mortality of blue sharks by developing a hook removal tool, which allowed up to 88 percent of the blue shark catch to be released alive. As a result, the requirement to develop a wholesale market for blue sharks was dropped in 1991 (Leet et al. 2001). Between 1991 and 1999, the commercial harvest of blue sharks dropped to 37,500 pounds (Leet et al. 2001).

The recreational catch of blue sharks grew tremendously throughout the 1980s. Estimated annual catch increased ten-fold between 1981 and 1988 with over 400,000 angler trips on private boats, which had "sharks" (including mako sharks) as the primary or secondary target species. Although angler effort for "sharks" remained high throughout the 1990s, blue shark harvest continually declined (Leet et al. 2001). This may be due to the fact that most blue sharks are released alive. The greatest source of fishing mortality for southern California blue sharks in the past three decades probably occurred as a result of their incidental capture during the developing years of the drift gillnet fishery for swordfish and thresher sharks. Annual estimated bycatch in the late 1970s and early 1980s was between 15,000 and 20,000 blue sharks (Leet et al. 2001). Changes in season length, fleet size, time-area closures and the use of large mesh nets substantially reduced blue shark mortality, although there are no reported estimates of current mortality in this fishery. The Southern California Bight is generally considered a nursery area for immature blue sharks (Leet et al. 2001).

T he size of California's blue shark stock is unknown. Local abundance undergoes major seasonal fluctuations with juveniles to three year olds most abundant in the coastal waters from early spring to early winter. Mature adults are uncommon in coastal waters (Leet et al. 2001).

Opah (*Lampris guttatus*)

Opah occur worldwide in temperate and tropical seas. In the eastern Pacific, they occur from Chile to the Gulf of Alaska (Leet et al. 2001). All life stages of this species are pelagic and oceanic, occurring from the sea surface to a depth of 1,680 feet. Seasonal movements are not known in the northeastern Pacific, but in the northeastern Atlantic opah catch has been reported in the North Sea and waters off Iceland solely during the summer (Leet et al. 2001). Opah are known to grow to at least 54 inches in length, but have been reported to reach 72 inches. They are known to reach a weight of at least 160 pounds and have been reported to reach 500 to 600 pounds. The maximum age of opah is unknown (Leet et al. 2001).

Between 1976 and 1989, only 1,660,856 pounds of opah were landed in California, with no landings in some years, and the largest landings following the 1982-1983 El Niño (516,126 pounds in 1984) (Leet et al. 2001). Between 1990 and 1999, approximately 1,470,653 pounds of opah were landed in California, with annual landings ranging from 81,669 to 246,530 pounds. The highest landings of the decade occurred in 1998; once again associated with a warm water event (the 1997-1998 El Niño) (Leet et al. 2001). Although the majority of opah landed in California since 1990 were landed from San Luis Obispo County south (about 50 percent from San Diego County alone), landings were reported as far north as Crescent City. Sport fishermen targeting albacore from British Columbia to Baja California occasionally catch opah. Within California, many sport caught opah are taken from the northern Channel Islands south to the Coronado Islands, just below the U.S.-Mexico border (Leet et al. 2001).

The size of the opah population, worldwide or off the coast of California is not known. Opah are probably solitary fish as few are encountered at any one time. It is not known whether local subpopulations exist or how far individual opah travel. Based upon trends over the last two decades, opah landings in California are likely to increase after El Niño events (Leet et al. 2001).

Louvar (*Luvarus imperialis*)

Louvar occur worldwide in temperate and tropical seas. In the eastern Pacific they are found from central Washington to Chile (Leet et al. 2001). Although generally uncommon, they are relatively abundant in southern California. All life stages of this species are pelagic and oceanic. Adults occur from the sea surface to a depth of 1,970 feet, but most are found at depths below 660 feet (Leet et al. 2001).

From 1990 through 1999, a total of 95,844 pounds were landed in California; annual landings ranged from 5,190 pounds in 1994 to 17,498 pounds in 1992 (Leet et al. 2001). Annual landings since the mid-1980s have shown fluctuations from year-to-year but overall have remained relatively stable, with an average of 10,923 pounds (1986-1989), and 9,584 pounds (1990-1999)(Leet et al. 2001). There is not a significant recreational fishery for louvar.

Dolphin (*Coryphaena hippurus*)

In the eastern Pacific, temperature seems to be an important factor in defining the range and possibly the movements of dolphin, the northern barrier being the California Current, and in the south, the Peru Current. Various authors report seasonal patterns in catches, possibly relating to spawning migrations or seasonal intrusion of preferred warm water temperatures. Norton (1999) noted the dramatic increase in recreational catches of dolphin off southern California and northern Mexico over the past 30 years (especially during the last decade). He suggested that the habitat of dolphin has been expanding northward in response to an oceanic and atmospheric regime shift that has brought periods of warmer water and enhanced northward current flow to California. It has also brought less cold water upwelling off northern Mexico, which had formerly inhibited northward dispersal. Length/age data from fish taken in the wild show dolphin have an average growth of about a 0.09 inches per day (Leet et al. 2001). In the western Pacific, dolphin reach a length of 15 inches the first year, 27 inches the second year, 35 inches the third year, and 43 inches the fourth year (Leet et al. 2001).

In commercial fisheries, an estimated average of 1,084 dolphin have been landed and 324 released per year by the high seas longline fishery landing in California during the period August 1,1995, through December 31, 1999 (Leet et al. 2001). It is occasionally taken by albacore bait and troll boats and tuna purse seine vessels. It is rare in the drift gillnet catch, possibly because its surface-swimming habits take it above the reach of the top of these nets (Leet et al. 2001).

Most recreational catches occur in the Southern California Bight, especially south of Los Angeles. Before 1972, the annual California commercial passenger fishing vessel (CPFV) catches during the July through October fishing season seldom exceeded a few hundred fish (Leet et al. 2001). Thereafter over 1,000 were taken in 23 of the next 25 seasons. A major shift occurred in 1990 when the catch exceeded 31,000 fish, and averaged 15,602 fish per year between 1990 and 1997 (range: 1,000 to 31,548)(Leet et al. 2001).

4.3.3.5 Seabirds and Shorebirds

Over 195 species of birds use open water, shore, or island habitats in the SCB south of Point Conception (Baird,1990). Many of these species are found in the project area (Table 4-3). The Channel Islands region is located along the Pacific Flyway, a major migratory route for birds, and acts as a stopover during both north (April through May) and south (September through December) migrations. The months of June and July are peak months for transient shorebirds (Lehman 1994). The Channel Islands provide breeding and nesting sites for many species and large numbers of seabirds, including many threatened and endangered species (Table 4-4). The diversity of habitats provided both on- and offshore also contributes to the high species diversity in the region (Figure 4-5). Sandy beaches provide foraging and resting habitat for a number of shorebirds including black-bellied plover, willet, whimbrel, long-billed curlew, gulls, and sanderlings. The upland potions of the beach provide kelp deposits that attract invertebrates where black and ruddy turnstones, dowitchers, and other shorebird species forage.

Table 4-3. Seabirds associated with the project area.

Common Names of Bird Families and Species	Scientific Names	Presence in project area*
Loons (offshore)	Family: Gaviidae	
Red throated Loon	*Gavia stellata*	Common visitor in winter; rare, but regular in summer
Pacific Loon	*Gavia pacifica*	Uncommon visitor in winter; abundant in spring; rare to locally uncommon in summer; common in fall
Common Loon	*Gavia immer*	Winter visitor; rare in spring; rare but regular in summer
Yellow-billed Loon	?	Casual winter visitor
Grebes (offshore)	*Family: Podicipedidae*	
Pied-billed Grebe	Podilymbus podiceps	Winter visitor; fairly common summer resident
Horned Grebe	*Podiceps auritus*	Winter visitor; very rare in summer
Red-necked Grebe	*Podiceps grisegena*	Winter visitor; very rare fall transient
Eared Grebe	*Podiceps nigricollis*	Winter visitor; very rare in summer
Western Grebe	*Aechmophorus occidentalis*	Winter visitor; several spring breeding records; uncommon to locally common in summer
Clark's Grebe	*Aechmophorus clarkii*	Winter visitor; several spring breeding records; very uncommon to locally common in summer
Albatrosses (offshore)	*Family: Diomedeidae*	
Black-footed Albatross	*Phoebastria nigripes*	Uncommon to rare visitor in fall/winter; uncommon in spring/summer
Laysan Albatross	*Diomedea immutabilis*	Rare but regular visitor in winter/summer/fall
Fulmars (offshore)	*Family: Procellariidae*	
Northern Fulmar	*Fulmarus glacialis*	Winter/spring/fall visitor; very rare in summer
Petrels (offshore)	*Family: Procellariidae*	
Mottled Petrel	*Pterodroma inexpectata*	Casual winter visitor offshore
Murphy's Petrel	*Pterodroma ultima*	Very rare visitor well offshore
Cook's Petrel	*Pterodroma cookii*	Casual winter visitor; very rare visitor well offshore in spring/summer
Stejneger's Petrel	*Pterodroma longirostris*	Casual winter visitor
Shearwaters (offshore)	*Family: Procellariidae*	
Pink-footed Shearwater	*Puffinus creatopus*	Very rare in winter; common visitor in spring/summer
Flesh-footed Shearwater	*Puffinus carneipes*	Casual visitor offshore
Buller's Shearwater	*Puffinus bulleri*	Very rare fall visitor well offshore
Sooty Shearwater	*Puffinus griseus*	Common to abundant visitor in spring/summer/fall; very rare but regular in winter
Short-tailed Shearwater	*Puffinus tenuirostris*	Very rare winter visitor
Black-vented Shearwater	*Puffinus opisthomelas*	Rare winter visitor; casual in spring/summer; common to uncommon in fall
Storm-Petrels (offshore)	*Family: Hydrobatidae*	
Wilson's Storm-Petrel	*Oceanites oceanicus*	Casual visitor
Fork-tailed Storm-Petrel	*Oceanodroma furcata*	Casual visitor in winter/spring
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Uncommon to common in winter/spring/fall; uncommon in summer, breeds on islands
Ashy Storm-Petrel	*Oceanodroma homochroa*	Casual visitor in winter; common resident in spring/summer/fall. Breeds on San Miguel and Santa Cruz Islands
Wedge-rumped Storm-Petrel	*Oceanodroma tethys*	Casual winter visitor
Black Storm-Petrel	*Oceanodroma melania*	Fairly common to common summer visitor, breeds on islands
Least Storm-Petrel	*Oceanodroma microsoma*	Irregularly uncommon to fairly common summer/fall visitor
Tropicbirds (offshore)	*Family: Phaethontidae*	
Red-billed Tropicbird	*Phaethon aethereus*	Very rare summer/fall visitor
Red-tailed Tropicbird	*Phaethon rubricauda*	Casual visitor

Common Names of Bird Families and Species	Scientific Names	Presence in project area*
Pelicans (onshore and offshore)	*Family: Pelecanidae*	
American White Pelican	*Pelecanus erythrorhynchos*	Rare to very rare winter visitor
California Brown Pelican	*Pelecanus occidentalis californicus*	Common year-round. Breeds on Anacapa, Santa Cruz, Santa Barbara islands
Cormorants (onshore and offshore)	*Family: Phalacrocoracidae*	
Double-crested Cormorant	*Phalacrocorax auritus*	Winter visitor, uncommon and local in summer, breeds on islands
Brandt's Cormorant	*Phalacrocorax penicillatus*	Common to very common winter visitor. Breeds on Channel Islands
Pelagic Cormorant	*Phalacrocorax pelagicus*	Fairly common to common winter visitor; fairly common summer resident, breeds on islands.
Frigatebirds (offshore)	*Family: Fregatidae*	
Magnificent Frigatebird	*Fregata magnificens*	Rare summer visitor
Geese (onshore and offshore)	*Family: Anatidae*	
Brant	*Branta bernicla*	Rare winter and fall visitor; common to abundant transient just offshore in spring; very rare in summer
Scoters (offshore)	*Family: Anatidae*	
Surf Scoter	*Melanitta perspicillata*	Common winter visitor; rare to uncommon in summer
White-winged Scoter	*Melanitta fusca*	Transient winter visitor
Plovers (onshore)	*Family: Charadriidae*	
Black-bellied Plover	*Pluvialis squatarola*	Common winter visitor; uncommon to fairly common but local in summer
American Golden Plover	*Pluvialis dominica*	Casual spring transient; rare in fall
Pacific Golden Plover	*Pluvialis fulva*	Very rare in winter; very rare transient in spring; rare in fall
Western Snowy Plover	*Charadrius alexandrinus*	Fairly common, but local winter visitor; spring resident; uncommon to fairly common but local in summer, breeds on islands.
Semipalmated Plover	*Charadrius semipalmatus*	Uncommon and local winter visitor; fairly common transient in spring/fall; a few individuals in summer
Killdeer	*Charadrius vociferus*	Common permanent resident year round, breeds on islands
Oystercatchers (onshore)	*Family: Haematopodidae*	
Black Oystercatcher	*Haematopus bachmani*	Uncommon permanent resident year round, breeds on islands
Stilts (onshore)	*Family: Recurvirostridae*	
Black-necked Stilt	*Himantopus mexicanus*	Uncommon to rare in winter; uncommon resident in summer
Avocets (onshore)	*Family: Recurvirostridae*	
American Avocet	*Recurvirostra americana*	Fairly common transient
Yellowlegs (onshore)	*Family: Scolopacidae*	
Greater Yellowlegs	*Tringa melanoleuca*	Fairly common to locally common winter visitor; rare in summer
Lesser Yellowlegs	*Tringa flavipes*	Very rare to rare in winter; uncommon to fairly common fall transient
Sandpipers (onshore)	*Family: Scolopacidae*	
Solitary Sandpiper	*Tringa solitaria*	Very rare to casual in spring; rare but regular fall transient
Willet	*Catoptrophorus semipalmatus*	Winter visitor; fairly common in spring/summer
Wandering Tattler	*Heteroscelus incanus*	Winter visitor; casual in spring/summer
Spotted Sandpiper	*Actitis macularia*	Winter visitor; rare summer resident
Little Curlew	*Numenius minutus*	Casual vagrant
Whimbrel	*Numenius phaeopus*	Fairly common to locally common winter visitor
Long-billed Curlew	*Numenius americanus*	Winter visitor; uncommon in spring/summer
Marbled Godwit	*Limosa fedoa*	Winter visitor; uncommon to rare in spring/summer
Ruddy Turnstone	*Arenaria interpres*	Winter visitor; very rare in summer

Common Names of Bird Families and Species	Scientific Names	Presence in project area*
Black Turnstone	*Arenaria melanocephala*	Winter visitor; very rare in summer
Surfbird	*Aphriza virgata*	Casual in winter; fairly common transient in spring; very rare in fall
Red Knot	*Calidris canutus*	Casual winter and summer transient
Sanderling	*Calidris alba*	Winter visitor; uncommon and local in summer
Semipalmated Sandpiper	*Calidris pusill*	Casual spring transient
Western Sandpiper	*Calidris mauri*	Common to uncommon but local in winter; very rare in summer
Least Sandpiper	*Calidris minutilla*	Winter visitor; casual in summer
Baird's Sandpiper	*Calidris bairdii*	Casual in spring; very uncommon fall transient
Pectoral Sandpiper	*Calidris melanotos*	Casual in spring; locally uncommon fall transient
Sharp-tailed Sandpiper	*Calidris acuminata*	Very rare fall transient
Dunlin	Calidris alpina	Winter visitor; uncommon spring transient; fairly common to locally common fall transient
Stilt Sandpiper	*Calidris himantipus*	Casual in spring; very rare fall transient
Buff-breasted Sandpiper	*Tryngites subruficollis*	Casual fall vagrant
Ruff	*Philomachus pugnax*	Winter visitor; very rare fall transient
Short-billed Dowitcher	*Limnodromus griseus*	Very rare winter/spring transient
Long-billed Dowitcher	*Limnodromus scolopaceus*	Winter visitor; casual in summer
Common Snipe	*Gallinago gallinago*	Winter visitor
<u>Phalaropes (onshore)</u>	*Family: Scolopacidae*	
Wilson's Phalarope	*Phalaropus tricolor*	Uncommon to fairly common spring transient; fairly common to common fall transient
Red-necked Phalarope	*Phalaropus lobatu*	Common to locally abundant spring transient; rare in summer; common fall transient
Red Phalarope	*Phalaropus fulicaria*	Absent to fairly common winter visitor; rare to abundant in spring; very rare in summer; uncommon to common in fall
<u>Jaegers (offshore)</u>	*Family: Laridae*	
Pomarine Jaeger	*Stercorarius pomarinus*	Uncommon in winter, casual in summer
Parasitic Jaeger	*Stercorarius parasiticus*	Rare but regular winter visitor, casual in summer
Long-tailed Jaeger	*Stercorarius longicaudus*	Uncommon to rare fall transient
<u>Skuas (offshore)</u>	*Family: Laridae*	
South Polar Skua	*Catharacta maccormicki*	Rare spring/fall visitor well offshore; casual in summer
<u>Gulls (onshore and offshore)</u>	*Family: Laridae*	
Laughing Gull	*Larus atricilla*	Casual vagrant
Franklin's Gull	*Larus pipixcan*	Casual in winter/summer; very rare transient in spring/fall
Little Gull	*Larus minutus*	Casual vagrant
Common Black-headed Gull	*Larus ridibundus*	Casual vagrant in fall/winter
Bonaparte's Gull	*Larus philadelphia*	Winter visitor; rare in summer
Heermann's Gull	*Larus heermanni*	Common winter visitor; uncommon spring visitor
Mew Gull	*Larus canus*	Locally common winter visitor; casual in summer
Ring-billed Gull	*Larus delawarensis*	Common winter visitor; fairly common in summer
California Gull	*Larus californicus*	Common winter visitor; fairly common to locally common in summer
Herring Gull	*Larus argentatus*	Very uncommon to locally fairly common in winter; casual in summer
Thayer's Gull	*Larus thayeri*	Rare to locally winter visitor
Western Gull	*Larus occidentalis*	Common resident year round. Breeds along along North Coast and Channel Islands
Glaucous-winged Gull	*Larus glaucescens*	Uncommon to fairly common winter visitor; rare but somewhat regular in spring/summer
Glaucous Gull	*Larus hyperboreus*	Very rare winter visitor
Black-legged Kittiwake	*Rissa tridactyla*	Irregular winter visitor; offshore transient in spring

Common Names of Bird Families and Species	Scientific Names	Presence in project area*
Sabine's Gull	*Xema sabini*	Uncommon spring/fall transient; casual in summer
Terns (onshore and offshore)	*Family: Laridae*	
Gull-billed Tern	*Sterna nilotica*	Casual visitor
Caspian Tern	*Sterna caspia*	Very rare to rare in winter; fairly common summer visitor
Royal Tern	*Sterna maxima*	Fairly common winter visitor; uncommon in spring; casual in summer; fairly common transient in fall
Elegant Tern	*Sterna elegans*	Casual in winter; rare in spring; common in summer/fall
Common Tern	*Sterna hirundo*	One winter record; rare summer visitor
Arctic Tern	*Sterna paradisaea*	Rare in spring; uncommon fall transient well offshore
Forster's Tern	*Sterna forsteri*	Common winter visitor; common transient and uncommon to fairly common summer visitor
California Least Tern	*Sterna antillarum brownii*	Fairly common but local resident in summer
Black Tern	*Chlidonias niger*	Rare and declining
Skimmers (onshore and offshore)	*Family: Laridae*	
Black Skimmer		Very rare visitor, increasing
Alcids (onshore and offshore)	*Family: Alcidae*	
Common Murre	*Rhynchops niger*	Uncommon to common winter transient and offshore visitor; rare in spring/summer
Pigeon Guillemot	*Cepphus columba*	Casual in winter/spring/fall; common summer resident. Breeds on North Coast and Channel Islands
Marbled Murrelet	*Brachyramphus marmoratus*	Very rare visitor in winter/summer/fall; casual in spring
Xantus's Murrelet	*Synthliboramphus hypoleucus*	Very rare in winter/fall; common resident offshore in spring/summer. Breeds on Channel Islands
Craveri's Murrelet	*Synthliboramphus craveri*	Very rare summer/fall visitor offshore
Ancient Murrelet	*Synthlibormaphus antiquus*	Rare and irregular winter visitor; casual in spring/summer
Cassin's Auklet	*Ptychoramphus aleuticus*	Widespread in winter; locally common in summer. Breeds on Channel Islands
Parakeet Auklet	*Cyclorrhynchus psittacula*	Casual vagrant well offshore
Rhinoceros Auklet	*Cerorhinca monocerata*	Fairly common to common transient and visitor. Breeds at Point Arguello
Tufted Puffin	*Fratercula cirrhata*	Very rare visitor well offshore in winter/spring/fall, breeding records from the islands.
Horned Puffin	*Fratercula corniculata*	Casual spring visitor well offshore

**Common to Abundant*: 15 or more individuals per day in the proper habitat
Uncommon to Fairly Common: 1-15 individuals per day in the proper habitat
Rare or Infrequent: 1-15 individuals per season in the proper habitat
Very Rare or Very Infrequent: average of fewer than 1 record per season
Casual: 2-10 records total for Santa Barbara County
Accidental: 1 record for Santa Barbara County
Source: The Birds of Santa Barbara County, California by Paul E. Lehman (1994, Vertebrate Museum, University of California, Santa Barbara)

Table 4-4. Seabird, shorebird, and wading bird species breeding in the project area

Common Name	Scientific Name
Western Grebe	*Aechmophorus occidentalis*
Clark's Grebe	*Aechmophorus clarkii*
Ashy Storm-Petrel	*Oceanodroma homochroa*
Black Storm-Petrel	*O. melania*
Leach's Storm-Petrel	*O. leucorhoa*
California Brown Pelican	Pelecanus occidentalis californicus
Double-crested Cormorant	*Phalacrocorax auritus*
Brandt's Cormorant	*P. penicillatus*
Pelagic Cormorant	*P. pelagicus*
Great Blue Heron	Ardea herodias
Snowy Plover	*Charadrius alexandrinus*
Killdeer	*Charadrius vociferus*
Black Oystercatcher	*Haematopus bachmani*
Western Gull	*Larus occidentalis*
Pigeon Guillemot	*Cepphus columba*
Xantus's Murrelet	*Synthliboramphus hypoleuca*
Cassin's Auklet	*Ptychoramphus aleuticus*
Rhinoceros Auklet	*Cerorhinca* monocerata
Tufted Puffin	*Fratercula cirrhata*

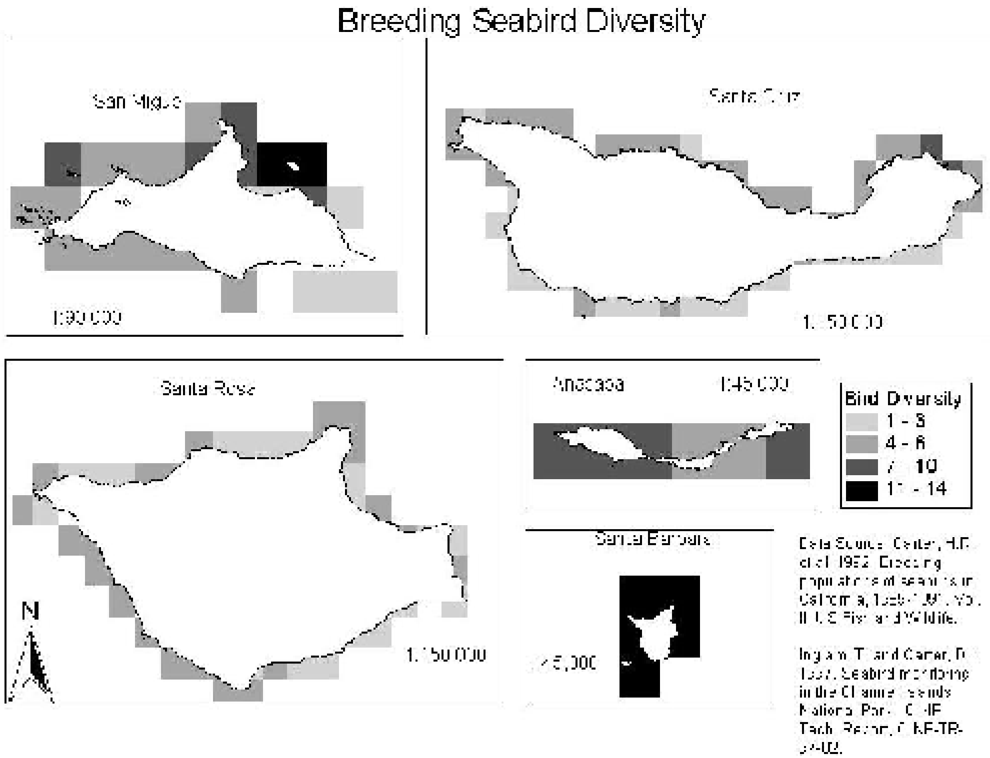

Figure 4-5. Distribution of breeding seabird diversity in the project area.

Seabird occurrence in the open ocean (more than 1 kilometer offshore) is correlated to with currents and submarine topography. Water temperature affects seabird abundance as it affects upwelling. Near the Channel Islands region, upwelling occurs regularly in the waters off Point Conception, Arguello Canyon, and along the Santa Rosa-Cortez Ridge (Lehman,1994). In addition, certain seabirds frequent waters that have a specific range of temperatures. This is correlated to rare or one-time sightings of sub-tropical seabirds from the south when water temperatures become abnormally warm, and of cold-water seabirds from the north when waters become abnormally cool. Kittiwakes and fulmars have been observed in late winter and early spring when waters reach minimum temperature (Lehman,1994). Seabirds range over the open ocean, nearshore waters, bays, harbors, and rocky beaches.

Birds depend on healthy coastal and marine habitats in the project area. Shorebirds, for example, feed and roost in many of the coastal areas of the northern Channel Islands. Sandy beaches provide foraging and resting habitat for a number of shorebirds including black-bellied plover, willet, whimbrel, long-billed curlew, gulls, and sanderlings. Figure 4-6 depicts the spatial transitional areas that exist between the subtidal, intertidal and upland areas that birds depend on for feeding and reproduction. The upland potions of the beach provide kelp deposits that attract invertebrates where black and ruddy turnstones, dowitchers, and other shorebird species forage.

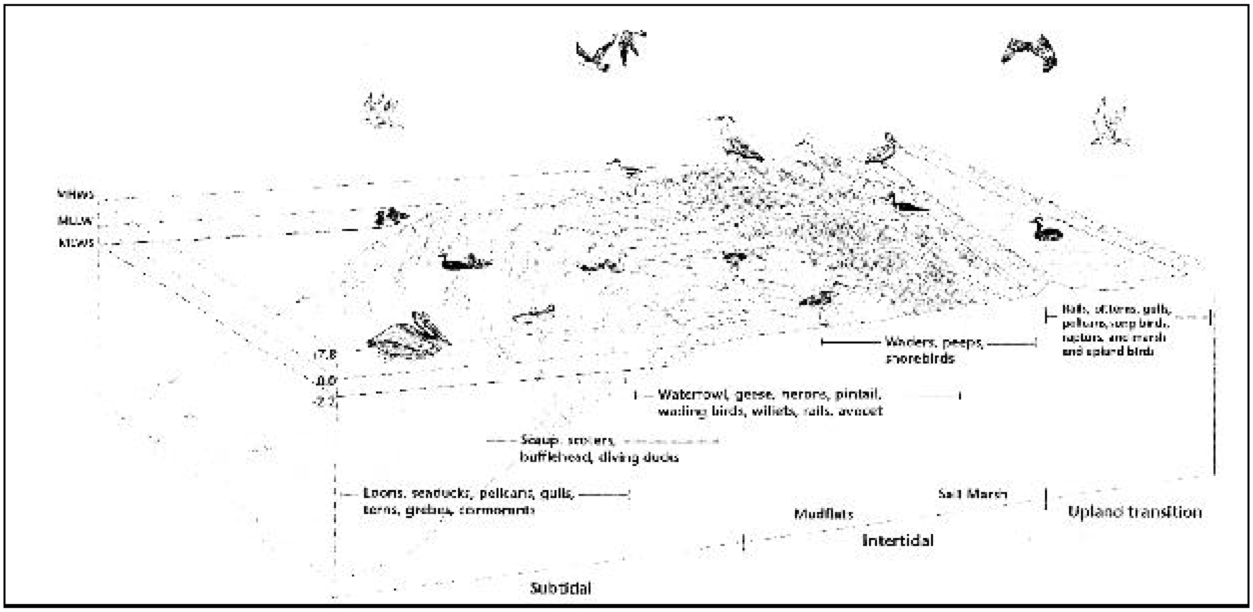

Figure 4-6. Important transition areas used by birds in the project area.

Special-Status Bird Species

Several species within the project area have special status under Federal or State law (Table 4-5). For several species that are listed as threatened or endangered, the northern Channel Islands represent designated critical habitat areas. Birds depend on a healthy coastal marine environment for survival, and feed near shore on small fishes associated with the Sanctuary. Additional descriptive information on many of these species is presented below.

Table 4-5. Birds with special status under Federal or California State law commonly found in the project area.

Common Name	Scientific Name	Status*
Ashy storm-petrel	*Oceanodroma homochroa*	Federal Species of Concern, California Special Concern, Department of Fish and Game
Black storm-petrel	*Oceanodroma melania*	California Special Concern, Department of Fish and Game
California brown pelican	*Pelecanus occidentalis californicus*	Federally Endangered, State Endangered, Department Fully Protected Species
California least tern	*Sterna antillarum browni*	Federally Endangered, State Endangered, Department Fully Protected Species
Common loon	*Gavia immer*	California Special Concern, Department of Fish and Game
Double-crested cormorant	*Phalacrocorax auritus*	California Special Concern, Department of Fish and Game
Fork-tailed storm-petrel	*Oceanodroma furcata*	California Special Concern, Department of Fish and Game
Rhinoceros auklet	*Cerorhinca monocerata*	California Special Concern, Department of Fish and Game
Western snowy plover	*Charadrius alexandrinus nivosus*	Federally Threatened
Xantus' murrelet	*Synthliboramphus hypoleucus*	Federal Species of Concern, California Special Concern, Department of Fish and Game

Leach's storm-petrel (*Oceanodroma leucorhoa*)

Leach's storm-petrel is a migratory breeding seabird and is identification by the Office of Oil Spill Prevention and Response (OSPR) as a species sensitive to oil spill. Leach's storm-petrel is approximately 8 inches long and is dark brown above and below. In flight, the legs do not extend beyond the forked tail. Most birds have a triangular, dusky white rump patch, bisected by dark feathers (Audubon 1988).

Leach's storm petrel is fairly common along the Pacific coast, uncommon south of breeding range along Atlantic coast, and has a highly restricted breeding range. It inhabits coastal islands and open sea. In the Channel Islands, Leach's storm-petrels bred on Santa Barbara and San Miguel Islands (Lehman 1994). It is nocturnal in its breeding activities and nests in colonies found on coastal islands, such as those within the region. During the day, they nest in horizontal burrows that can be up to 1 meter long or are at sea foraging for food. This species feeds by hovering just above the water and swooping down to catch plankton, small fish, and squid (Ehrlich et al. 1988). One egg is laid anytime from early June to late July, and the incubation lasts 40 to 50 days, during which time both parents tend the egg. Winters are spent at sea, possibly in the tropics. (Nova Scotia Museum of Natural History 2000)

Ashy storm-petrel (*Oceanodroma homochroa*)

Ashy storm-petrels are small, highly pelagic, seabirds that prey on small invertebrates (young squid, euphausiids, crab larvae) and small fish while they flutter along at the ocean's surface. Ashy storm-petrels are restricted to the north-east Pacific Ocean, breeding on islands from central to southern California (with a few small colonies in Baja California and northern California). Approximately one-half of the world population, estimated at less than 10,000 individuals, nest at the Farallon Islands and half in the Channel Islands, primarily at San Miguel, Santa Barbara, and Santa Cruz islands (Carter et al. 1992). The breeding period is from April through November, although birds may visit their nesting colonies year-round. Dispersal in the non-breeding season is thought to be limited. Large numbers congregate each fall in Monterey Bay. Populations of ashy storm-petrels have declined by an estimated 34 percent over the past 20 years at the Farallon Islands (Sydeman et al. 1998a,b) (long-term trends are not available for the Channel Islands population). Factors in the decline include habitat loss from invasive non-native plants; introduction of feral cats, house mice, and other nonnative animals; decline in zooplankton in the SCB; and predation by house mice, western gulls, burrowing owls, and other owl species (Sydeman et al. 1998; Nur et al. 1999). Ashy storm-petrels are also known to be sensitive to human disturbance, oil pollution, and marine pollution.

Black storm-petrel (*Oceanodroma melania*)

Black storm-petrels are found in the north-east Pacific Ocean. They primarily breed on islands of the coast of Baja California and in the Gulf of California (Harrison 1983). A small population, estimated at 274 individuals, breeds from April to October on Santa Barbara Island in Santa Barbara County (Carter et al. 1992). After breeding, birds generally move south towards northern South America, however, in warm-water years large numbers move as far north as Monterey and Point Reyes (Harrison 1983).

California brown pelican (*Pelecanus occidentalis californicus*)

The California brown pelican was listed as an endangered species under the ESA in 1970 and by the Commission in 1971 because of decreased population numbers and extensive reproductive failures. These resulted from the effects of DDT and other chlorinated hydrocarbons in the late 1960s. Additionally, they are a fully protected species under Fish and Game Code Section 3511. California brown pelicans are found in estuarine, marine subtidal, and pelagic waters along the California coast. California brown pelicans breed in the Southern California Bight (SCB) at West Anacapa Island, Ventura County, and Santa Barbara Island, Santa Barbara County, in the Channel Islands and several islands off Baja California, Mexico. During the non-breeding season birds disperse along the coast, as far north as Vancouver, British Columbia and south to El Salvador.

California brown pelicans are colonial nesters and require nesting grounds free from human disturbance and mammalian predators, and must be in proximity to adequate food supplies (Gress and Anderson 1983). Nest sites are located on steep, rocky slopes and bluff edges and are comprised of sticks or debris. Communal roost sites are essential habitat for California brown pelicans (Gress and Anderson 1983) because, unlike other seabirds, California brown pelicans have wettable plumage (Rijke 1970) which can become heavy and hypothermic in cold water if they do not come ashore regularly to dry and recondition their plumage. Roost site selection is based on minimal disturbances and microclimate features that aid in thermoregulation. California brown pelicans congregate in traditional high quality roosts at night with major night roosts supporting hundreds to thousands of pelicans (Briggs et al. 1987). Substantial numbers (averaging in the thousands) roost on South Farallon Island and feed in the surrounding waters during the fall and winter.

California brown pelicans are diving birds that feed almost exclusively on fish and dive from 6 to12 m (6.6-13.2 ft) in the air (Johnsgard 1993). The main prey items in California are northern anchovies, Pacific sardines, and Pacific mackerel. After the collapse of the sardine fishery in the 1950s, northern anchovies were found to comprise 92 percent of the diet of California brown pelicans nesting in the SCB (Gress et al. 1980; Gress and Anderson 1983). In recent years however, Pacific sardine populations have been increasing and may now be common items in the California brown pelican diet.

<u>Double-crested cormorant</u> (*Phalacrocorax auritus*)

The double-crested cormorant is a California species of special concern. The double-crested cormorant is 26 to 32 inches in length. Adult plumage is black with iridescent green and purple above. The unfeathered throat pouch is yellow-orange, and the bill and feet are black. Juveniles are pale brown above with varying amounts of white below. The throat pouch and lower mandible are yellow and sometimes the upper mandible is yellow as well. The iris is brown in juveniles and blue-green in breeding adults. This species has a long tail and flies with a distinctive crook in its neck (Audubon 1988).

This migratory breeding seabird is a highly adaptive colonial breeder that utilizes a variety of habitats and is found both on the coast and inland. Breeding locations may change from year to year. This species breeds in the Aleutian Islands, Alaska and southwards along the Pacific coast, to Baja California, Mexico. This species breeds on Santa Barbara, Anacapa and San Miguel Islands (Lehman 1994). Double-crested cormorants feed on schooling fish, aquatic invertebrates, and, rarely, small invertebrates. This species uses wetland to open water habitats, and nests along seacoasts, on coastal cliffs and around rivers, marshes, and lakes. The birds build a platform nest of sticks, seaweed and other materials on the ground or in trees (Ehrlich et al. 1992).

Brandt's cormorant (*Phalacrocorax penicillatus*)

Brandt's cormorant is 28 to 31 inches in length, has brownish black feathers, and has black bills, legs, and feet. The head is large and distinctly thicker than the crest. The bill is long and stout. In breeding plumage, adults have a sky blue, bare throat pouch bordered by yellowish throat feathers and bristly white plumes that form eyebrows. Juveniles are dark brown with a "V" of tan to buff color on the upper breast that extends toward the lower breast and belly. The eye is dark in immature birds, and bright blue in breeding adults (Audubon 1988).

A migratory breeding seabird, the species ranges from the northeastern Pacific Ocean from southern Alaska south to Baja and the Pacific coast of Mexico. Brandt's cormorant breeds on Santa Barbara, San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands (Lehman 1994). This species breeds colonially on islands and gently sloping hillsides. Brandt's cormorants feed by diving and capturing fish and squid. They forage principally in nearshore waters less than 50 m in depth, at short distances from nesting or roosting sites (Ainley et al. 1981; Hebshi 1998). Nests are built in rocky areas along seacoasts and are less often built inshore in coastal wetlands (Ehrlich et al. 1988).

Pelagic cormorant (*Phalacrocorax pelagicus*)

The pelagic cormorant is 20 to 23 inches in length with a head that is barely thicker than the neck. The bill is distinctly slender and at all ages is dark in coloration (Audubon 1988). Adults are dark, with green iridescense on the feathers of the back and wings, and with varying amounts of purple on the neck. During the breeding season, adults have a red throat pouch, white patches on the flanks, and a "double-crested" appearance. Juveniles are darker and more uniformly colored, being entirely blackish-brown with occasional medium brown feathers on the sides and back of the neck.

The pelagic cormorant ranges from the North Pacific Ocean from northern Japan along Eastern Pacific coastal states, south to Baja California. This species breeds on Santa Barbara, San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands (Lehman1994). This species feed by diving for solitary fish (Ehrlich et al. 1988). They forage principally in nearshore waters less than 50 m in depth, at short distances from nesting or roosting sites (Ainley et al. 1981, Hebshi 1998).

Western snowy plover (*Charadrius alexandrinus*)

The Pacific coast population of the western snowy plover was federally listed as threatened on March 5, 1993. A recovery plan is currently being prepared. The final rule listing the western snowy plover as threatened describes its biology and reasons for its decline (58 Federal Register 42: 12864). Critical habitat was designated for the western snowy plover and includes all suitable habitat from Point Sal to Point Conception including Vandenberg AFB, the Santa Ynez River mouth, and Jalama Beach; Santa Barbara coast beaches including Devereux Beach (Coal Oil Point), Santa Barbara Harbor Beach, and Carpinteria Beach; Oxnard lowlands beaches including San Buenaventura Beach, Mandalay Bay/Santa Clara River mouth, Ormond Beach, and Mugu Lagoon; and the Channel Islands including San Nicolas Island beaches (65 Federal Register 64:68508). In addition, the coastal population of the western snowy plover is a California Species of Special Concern, and on the Audubon Society's Watch List.

The western snowy plover has gray-brown upper parts, a conspicuous patch on either side of the breast, a white eyebrow extending back from the forehead, a long thin black bill, and slate-colored legs. Adults have dark ear coverlets and breast patches, are blackish in breeding plumage, and gray-brown in winter. Breeding birds have a black bar across the forecrown as well. Juveniles have paler ear coverlets and breast patches that are the same colors as the upper parts (Audubon 1988).

Western snowy plovers are migratory breeding shorebirds that forage on invertebrates in intertidal zones, the wrack line, dry sandy areas above the high tide line, salt pans, and the edges of salt marshes. They feed by quickly running, stopping to pick up food or probe the surf line. Western snowy plovers eat marine worms, small crustaceans, and at inland locations, eat insects. The Pacific coast population nests near tidal waters along the mainland coast and offshore islands from southern Washington to southern Baja California, Mexico. Most nesting occurs on unvegetated to moderately vegetated, dune-backed beaches and sand spits. Other less common nesting habitats include salt pans, dredged soils, and salt pond levees. Nest site fidelity is common. Nesting and chick rearing activity generally occur between March 1 and September 30. During the non-breeding season, western snowy plovers may remain at breeding sites or may migrate to other locations, with most wintering south of Bodega Bay, California. Many birds from the interior population winter on the central and southern coast of California.

<u>Killdeer</u> (*Charadrius vociferus*)

The killdeer is a small to medium-sized bird, usually reaching 9 to 11 inches. It is a compactly built bird, with a thick neck, large eyes, and a thin black bill. The killdeer is brown above and white below, and has two black bands across its breast. This shorebird has two black breast bands and a tail that extends beyond the wingtips. The rufous rump and uppertail coverlets are conspicuous during both display and flight. On the head, a black band separates the white on the forehead from the eyebrow. The legs are long and flesh colored, and the eye ring is bright red. Juveniles have a single breast band and two black collars border its white collar. The wings are black at the base and white at the tip. The face is brown and white with a large, dark eye (Audubon 1988).

The killdeer is found throughout North America, south to central Mexico, the West Indies, and the Pacific coast of South America. It is a hardy bird, wintering in much of its breeding range. The killdeer breeds in fields, pastures, and freshwater shores. It builds a shallow depression in the ground and lays four eggs (Microsoft Online Encyclopedia 2000).

<u>Black oystercatcher</u> (*Haematopus bachmani*)

The black oystercatcher is a breeding migratory shorebird, is also listed on the National Audubon Society's Watch List (Audubon 2000). Oystercatcher, the common name for any of about ten species of shorebirds, is closely allied to the plovers, and can be distinguished by its long, vertically flattened stout orange bill, dull pink legs of moderate length, and feet with short, thick toes (Microsoft Online Encyclopedia 2000). Black oystercatchers are 17 to 19 inches long with a stocky build. The entire plumage is blackish-brown and the eyes are yellow. Juveniles are browner than adults and have dusky bills that are orange at the base (Audubon 1988).

The black oystercatcher is confined to the Pacific coast of North America (Microsoft Online Encyclopedia 2000). This species is a resident on rocky shores and islands along the

Pacific coast from the Aleutians to Baja California, and feeds on limpets. The total population within the Western Hemisphere has been estimated at less than 11,000. Black oystercatchers prefer rocky coasts and islands like those found within the Sactuary.

Western gull (*Larus occidentalis*)

Western gulls breed colonially on rocky islands from Washington south through California to Baja California. The western gull breeds along the Pacific coast from British Columbia to central Baja, California, Mexico (Carter et al. 1992). The largest breeding numbers (estimated at about 61,800 birds) occur in California. The Farallon Islands in central California harbors the largest colony in the world and large numbers are also found in the Channel Islands (Carter et al. 1992). Western gulls do not disperse far from their breeding range in the winter. They are omnivorous and feed on garbage, fish, cephalapods (including market squid), euphausids, offal, and birds and eggs (including adult and chicks of auklets and petrels, gull chicks, and eggs). They feed on fish, shrimp, and aquatic invertebrates. Western gulls also eat eggs of other nesting seabirds and garbage. Nests are located on a rocky cliff or headland on the ground (Ehrlich et al. 1988). Eggs are laid in late April, chicks begin hatching in late May, and peak hatching occurs in June on both Santa Barbara Island and East Anacapa Island (Lehman 1994).

California least tern (*Sterna antillarum browni*)

The California least tern is federally and California state-listed as endangered. The California least tern is approximately 8 ½ to 9 ½ inches in length. In breeding plumage, adults have a broad white forehead framed by a black crown and a black line running from the crown through the eye to the base of the bill. The mantle and short, strongly forked tail are pearl gray. A long, thin wedge of black up the leading edge of the outer wing, formed by the two outermost primary feathers and coverlets, is conspicuous in flight. Both the narrow black-tipped bill and the feet are yellow. Winter adults retain the black head pattern, which is blurred by a mixture of black and white feathers. Juveniles have a largely white head with a black line through the eye and a black nape. The entire leading edge of the wing is dark. The bill is black and the legs are brown (Audubon 1988).

California least terns feed on fish, such as top smelt, and aquatic invertebrates. The California least tern is 1 of 12 recognized subspecies of the least tern, 3 of which inhabit the United States. The breeding range of this subspecies extends along the Pacific coast from San Francisco Bay, California, to Bahia de San Quintin, Baja California, Mexico. The California least tern is a migratory species that arrives in California by late April to breed and departs to unknown southerly locations by August. It nests in colonies on coastal, sandy, open areas, usually around bays, estuaries, and creek and river mouths. Nests are unlined open scrapes or depressions in the sand on open, flat beaches that the birds often adorn with small fragments of shell or pebbles. During the average 2l-day incubation period, the nest is tended continually by both parents. The adults tend flightless, but quite mobile, chicks for approximately three weeks after hatching. After fledging, the young California least terns do not become fully proficient at capturing fish until after they migrate from the breeding grounds. Adults and fledglings usually leave the breeding colony within about ten days of fledging (Ehrlich et al. 1989).

Pigeon guillemot (*Cepphus columba*)

Pigeon guillemots are 12 to 14 inches long with a rounded head, long pointed black bill, and thin neck. This species has light brown wing linings and a white wing patch on the secondary coverlets that may have one or two black wedges. The feet and mouth lining are orange-red year-round. Breeding birds are black, becoming mottled gray and white throughout the winter. Juveniles are dusky gray above and have smaller wing patches (Audubon 1988).

The pigeon guillemot breeds from northeast Siberia, Alaska and British Columbia to several areas within Southern California, including Vandenberg AFB; Point Conception; possibly Hollister Ranch; and San Miguel, Santa Rosa, Santa Cruz, Santa Barbara, and Anacapa Islands (Lehman 1994). Prey items are fish and some shrimp that are caught by diving in deeper water a little offshore. This species breeds colonially or solitarily in cliffs and slopes, occasionally excavating a burrow. At 2 years old, guillemots first breed, and adults usually have high annual survivorship. When nests are relocated, it is usually over small distances (less than 30 meters) and nest site fidelity of breeding pairs is normally high. Eggs are usually laid in natural crevices and holes, about 50 centimeters from the nest crevice. Normally, two-egg clutches are laid and two chicks are raised per nesting attempt. Adults forage within 5 kilometers of the nest site in the subtidal and nearshore zones and whole fish are carried in their bills to the nest to feed the young. The young are raised almost entirely on fish, mostly on nearshore demersal fish (blennies, sculpins) and on nearshore schooling fish (sandlance). The broods are fed in the nest until the young reach adult body size.

Xantus's murrelet (Synthliboramphus hypoleucus)

Xantus's murrelets are considered an California species of special concern and are a globally rare seabird species (one of the ten rarest seabird species in the North Pacific). Petitions have been made to list this species under both the Federal and State ESA, due to its small population size and limited breeding range, as well as declining world population size (estimated as less than 10,000 birds) and known threats to colonies. Xantus's murrelets are small birds that feed on larval fish including northern anchovies, sardines, rockfish, Pacific sauries, and crustaceans, and forage in the immediate vicinity of the colony during the nesting season (Hunt et al. 1979). The world population of Xantus's murrelet only breeds from the Channel Islands south to Central Baja Calfornia, Mexico. Eighty percent of the United States breeding population and 33.5 percent of the world's breeding population nest in the Channel Islands, primarily at Santa Barbara Island (also found at San Miguel, Santa Cruz, and Anacapa islands). They return to the nesting islands in February and disperse from the islands by mid-July. They nest in rock crevices along steep cliff edges, under bushes, on the ground in vegetation, in burrows, under debris piles, and under human made structures. Daylight hours are spent on nests or foraging at sea, whereas nest site selection, incubation shift changes, and fledging all occur under cover of night (Hunt et al. 1979). Chicks depart to the sea with their parents at night at 2 days of age and are dependent on their parents for an extended period of time (Gaston and Jones 1998). Chicks that get lost or separated from their parents at night, or those who leave the nest during the day, are often fed upon by predators (e.g., western gulls).

Cassin's auklet *(Ptychoramphus aleuticus*)

Cassin's auklet are found along the Pacific coast, breeding from the Aleutian Islands in Alaska to central Baja California, Mexico (Carter et al. 1992). In California, they nest in rock crevices and burrows on offshore rocks and islands in northern California, at the Farallon Islands in central California, and at the Channel Islands in southern California (Anacapa, Santa Barbara, San Miguel, and Santa Cruz islands). The largest breeding colony is found at the South Farallon islands (Carter et al. 1992). There numbers in decline in the Channel Islands and the Farallons and are being considered for inclusion on the California species of special concern list. They fed largely on crustaceans (primarily euphausiids) but also consume fish and squid (Ainley et al. 1990). Cassin's auklets are nocturnal in their colony visits and chicks fledge the colony at night.

Rhinoceros auklet (*Cerorhina monocerata*)

The rhinoceros auklet is a California species of special concern. This species is approximately 15 inches in length with plumage that is sooty brown above and a grayish-brown throat, breast, sides, and flanks. Two stripes of white plumes run backward across the face; one from the base of the bill below the eye, and one just above and behind the eye. The bill is reddish-orange with a pale knob at the base of the lower mandible. In winter, the facial stripes and knob on the bill are absent. Juveniles are darker in color, with a smaller, darker bill similar to the winter plumage adult (Audubon 1988).

The rhinoceros auklet is a pelagic migratory breeding seabird common along most of the West Coast in fall and winter. It breeds colonially in burrows in maritime and inland grassy slopes, occasionally on flat ground on forest floors, usually with other alcids, in areas from the western Sea of Okhotsk, Sakhalin, and the southern Kuril Islands south of Japan and northeast Korea. They also breed from the Aleutians east to southern Alaska, south through British Columbia and Washington to California. This species is often seen in large numbers close inshore and feeds on mostly small fish and some squid. Rhinoceros auklets breed on several of the Channel Islands (Lehman 1994).

Tufted puffin (*Fratecula cirrhata*)

The tufted puffin is considered a California species of special conern by the Department. While colonies are found along the coasts of the north Pacific Ocean, only a small number, estimated at 276 birds, breds in California (Carter et al. 1992). They nest on offshore islands in northern California, at the Farallon Islands and Point Reyes in central California, and have recently recolonized southern California, in the Channel Islands, where they had not been seen since the early 1900s (Carter et al. 2001). Puffins have been seen at Prince Island, offshore San Miguel Island. Tufted puffins feed on medium-sized fish, crustaceans and squid, by diving and pursuing their prey underwater (Cogswell 1977). Diet studies in the Gulf of the Farallones found market squid to be a predominate prey item, along with anchovies and rockfish (Ainley et al. 1990). Tufted puffins are colonial nesters who nest in burrows on island cliffs or on grassy island slopes and may visit the nest burrow in daylight hours. Tufted puffins lay one egg which is incubated for about 45 days. The semiprecocial young is tended by both parents and remains in the burrow for close to two months. Fledglings depart for the sea alone, at night (Gaston and Jones 1998).

4.3.3.6 Sea Turtles

Five species of sea turtles have been reported in the offshore southern California region. Four of these are members of the family Cheloniidae while one is the only living member of the family Dermochelidae. The chelonids include the green sea turtle (*Chelonia mydas*), the hawksbill sea turtle (*Etremochelys imbricata*), the loggerhead sea turtle (*Caretta caretta*), and the olive Ridley sea turtle (*Lepodochelys olivacea*). The only dermochelid is the leatherback sea turtle (*Dermochelys coriacea*).

The normal range of the leatherback sea turtle extends from Chile northward to Alaska. The leatherback is the sea turtle species most commonly seen off the coast of California. The normal range of the other species does not extend north of Baja California, but individuals have been sighted or caught farther north.

None of the five sea turtles is known to nest on the west coast of America. With all five species, sporadic sightings of turtles have been made within United States waters. In general, little is known about migration routes and normal movements of sea turtles while at sea.

All sea turtles are protected by the ESA; hawksbill and leatherback sea turtles are listed as endangered. The other three species are listed as threatened in America. In Mexico, the nesting populations of green and olive ridley sea turtles are listed as endangered.

4.3.3.7 Marine Mammals

The Channel Islands and surrounding waters support a great diversity of marine mammals. The marine mammals discussed in this section represent three orders and suborders: Cetacea--whales dolphins and porpoises; Pinnipedia--seals, sea lions and fur seals; and Carnivora, which in this case is represented only by the southern sea otter (Enhydra lutris nereis), a member of the family Mustelidae. Cetaceans live their entire lives at sea, while pinnipeds come ashore periodically to rest, breed, bear young, or molt. In California, sea otters normally spend their entire lives at sea, though some do haul out on land, whereas in Alaska, they sometimes haul themselves out of the water.

All pinnepeds and cetaceans are protected under the Marine Mammal Protection Act of 1972 (MMPA). In addition, some species are listed under the MMPA as depleted or strategic stocks. Finally, some species are listed as threatened and endangered under the Federal and State ESA. Species with special protected status, which extends beyond being protected under the MMPA, are listed in section 4..

As in the case of birds, the abundance and distribution of marine mammals is an important indication of the general health and ecological integrity of the marine ecosystems of the Sanctuary. Marine mammals feed on fishes and invertebrates, which feed on other marine life of the northern Channel Islands. In general, the distribution and abundance of mammals, fishes and other marine life depend on healthy marine habitats, such as kelp forests and associated rocky reef ecosystems. For example, sea lions depend directly on fish and invertebrate prey, which then in turn depend on linkages with lower trophic levels (Figure 4-7).

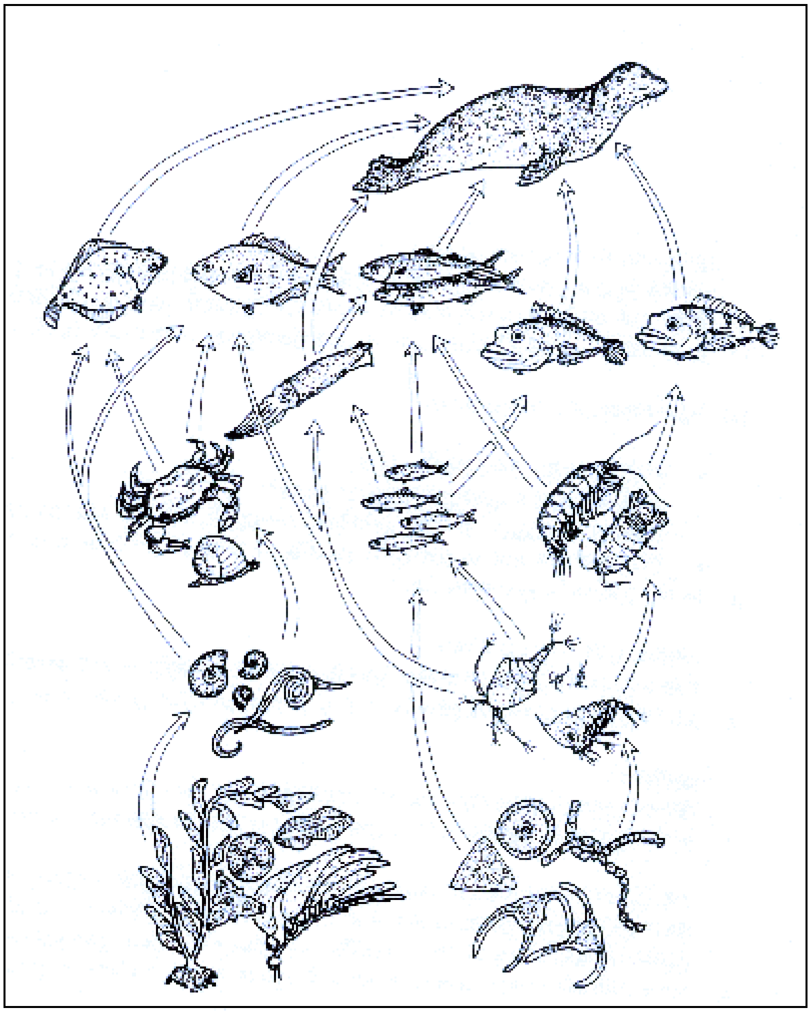

Figure 4-7. Simplified food web showing linkages between harbor seal and other marine life, including fishes, in the project area.

Mammals, in turn, are important to healthy marine ecosystems because, for example, they distribute important nutrients and foods throughout the marine environment that other marine life depend on for survival. Pinnepeds depend on several haulout and rookery sites throughout the Channel Islands (Figure 4-8). This section describes the species of marine mammals that are known to occur in the Channel Islands, including population status, protected status, regional distribution, and seasonality of each species.

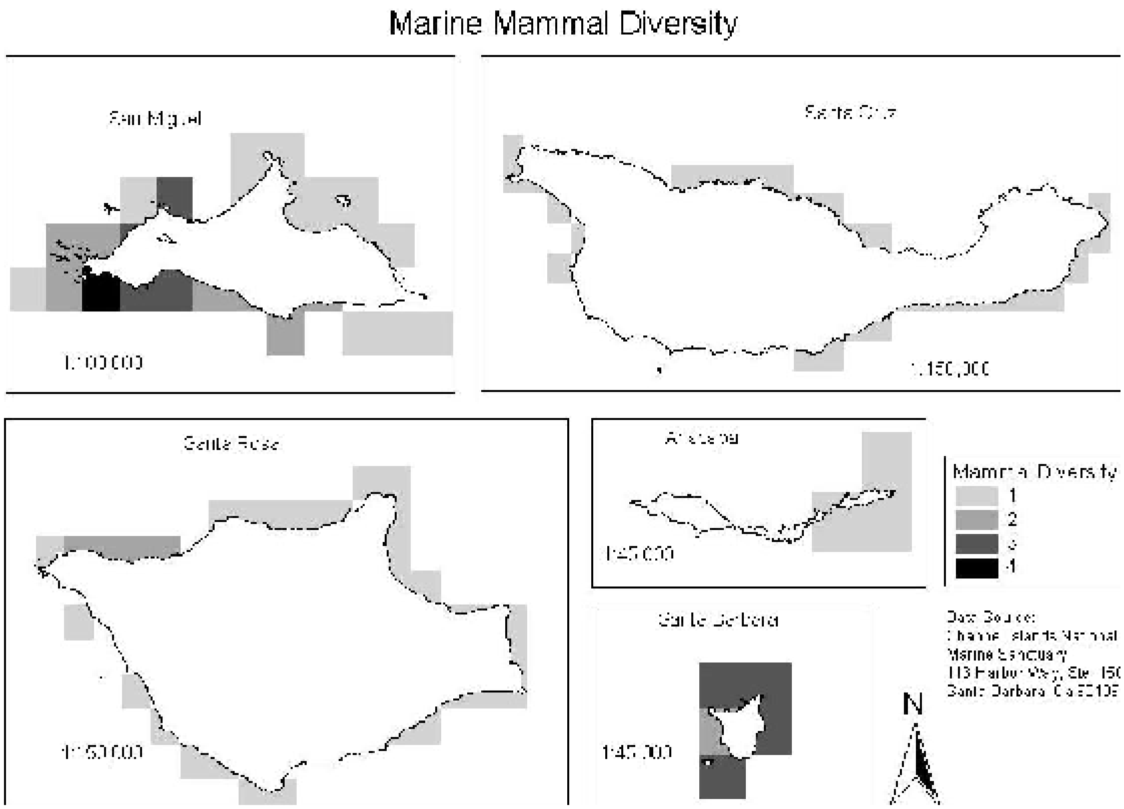

Figure 4-8. Distribution of the number of marine-mammal species found in haul-out and rookery sites in the project area.

Cetaceans

At least 33 species of cetaceans have been reported in the region (Leatherwood et al. 1982; Leatherwood et al. 1987). Most of the reports involve live sightings although a few are known only from strandings. The toothed whales, or odontocetes, number 25 species. Only eight species of baleen whales, or mysticetes, have been reported. Two of these are in their own families. The northern right whale (*Eubalaena glacialis*) is the only representative of the family Balaenidae that has been reported in the project area. The California gray whale (*Eschrichtius robustus*) is the sole surviving representative of the family Eschrichtiidae. The other six species are all members of the family Balaenopteridae, more often simply called rorquals.

Of the odontocetes, seven species are commonly seen, either during certain seasons or year-round. Common species include the long-beaked common dolphin (*Delphinus capensis*), the short-beaked common dolphin (*Delphinus delphis*), the onshore and offshore stocks of bottlenose dolphins (*Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), and Dall's porpoise (*Phocoenoides dalli*). The latter two species are generally associated with colder water masses (approximately 16 degrees C).

Odontocetes: Oceanic dolphins

Table 4-6. Cetaceans: Odontocetes - Oceanic Dolphins in the project area

Common Species Name (Scientific Name)	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
Long-beaked common dolphin *(Delphinus capensis)*	Stock size: 89,800	Protected under MMPA	Common	Year round	Coastal - up to 300 nautical miles offshore
Short-beaked common dolphin (*Delphinus delphis)*	Stock size: 372,000	Protected under MMPA	Common	Year round	Coastal - up to 50 nautical miles offshore
Bottlenose dolphin *(Tursiops truncatus)* Offshore stock	Stock size: 2,555	Protected under MMPA	Common	Year round	Shelf, slope and offshore
Bottlenose dolphin *(Tursiops truncatus)* Coastal stock	Stock size: 140	Protected under MMPA	Common	Year round	Surf zone up to 1km offshore
Pacific white-sided dolphin (Lageno-*rhynchus obliquidens*)	Population: 12,1693	Protected under MMPA	Sporadically abundant	Usually summer and fall	Shelf to farther offshore
Rough-toothed dolphin *(Steno bredanensis)*	Not available for area	Protected under MMPA	Known only from a few strandings		Pelagic
Striped dolphin (*Stenella coeruleoalba)*	Not available for area	Protected under MMPA			Pelagic
Long-snouted spinner dolphin *(Stenella longirostris*)	Not available for area	Protected under MMPA	Possible during El Niño events		Pelagic
Spotted dolphin *(Stenella attenuata)*	Not available for area	Protected under MMPA	Known only from strandings		Pelagic
Northern right whale dolphin (*Lissodelphis borealis)*	Stock size: 21,332	Protected under MMPA	Sporadically abundant	Winter and spring	Continental shelf and slope
Risso's dolphin *(Grampus griseus)*	Stock size: 32,376	Protected under MMPA	Common	Year round	Shelf, slope and
Short-finned pilot whale *(Globicephala macro-rhynchus)*	Stock size: 970	Protected under MMPA	Uncommon	Most often summer and fall	Shelf, slope and offshore
Orca or Killer whale *(Orcinus orca)*	Stock size: 336	Protected under MMPA	Uncommon	Year round	Shelf, slope and offshore
False killer whale *(Pseudorca cressidens)*	Not available for region	Protected under MMPA	Rare		Shelf to offshore and pelagic

Long-beaked common dolphin (*Delphinus capensis*)

Two species of common dolphins, the long-beaked and the short-beaked, are found in the eastern north Pacific (Heyning and Perrin 1994). Prior to this time, only one species was recognized, the common dolphin (*Delphinus delphis*). (Some authorities recognized the long-beaked common dolphin as the "Baja neritic" form of common dolphin rather than as a separate species.) This recent change in taxonomy has presented difficulties in assessing long-term population or stock changes from surveys and censuses made before the change. Some authorities simply group the two species together as *Delphinus spp*., when discussing earlier work (Barlow et al. 1997).

Recent estimates place the population of long-beaked common dolphins in the region at 32,239 for animals in California, Oregon, and Washington (1991-1996 average) (Barlow 1997). This species ranges from the coast out to 300 nm and more offshore. It usually frequents water less than 28 degrees C. Its geographic range in the region extends from the tropics to Point Sal. It feeds primarily on Pacific hake (*Merluccius productus*) and northern anchovy (*Engraulis mordax*). Both species reportedly feed extensively at night, following the deep scattering layer (Leatherwood et al. 1987) although both species have also been observed feeding during the day.

<u>Short-beaked common dolphin</u> (*Delphinus delphis*)

The short-beaked common dolphin population has been estimated at 373,573 for animals in California, Oregon, and Washington (1991-1996 average) (Barlow 1997). This species is more coastal in distribution than the long-beaked common dolphin, usually staying within 50 nm. It feeds on Pacific hake, northern anchovy and market squid (*Loligo opalescens*).

<u>Bottlenose dolphin</u> (*Tursiops truncatus*)

Two stocks of bottlenose dolphins have been distinguished: the California coastal stock and the California-Oregon-Washington offshore stock. The coastal stock ranges from literally in the surf out to approximately 1 kilometer offshore (Barlow et al. 1997). During the 1982 to 1983 El Niño event, coastal bottlenose dolphins ventured into central California. They have been reported as far north as San Francisco. Their usual northern limit was once Los Angeles County. Since that time, bottlenose dolphins have remained in the coastal waters of Santa Barbara and San Luis Obispo counties. The southern limit of their range extends at least to Ensenada, Baja California Norte. Despite the extent of their range, the coastal stock is very small, with a mean estimate of only 169 animals (Forney et al. 2000). Coastal bottlenose dolphins feed on fish near the bottom.

In the general region, the offshore stock of bottlenose dolphins frequents the waters off Santa Catalina, San Clemente, and Santa Barbara Islands (Barlow et al. 1997) as well as the Santa Cruz Basin, which is south of Santa Cruz Island. The offshore stock occasionally ventures into the Santa Barbara Channel, usually in summer. The overall range extends from Mexico to northern California although bottlenose dolphins have been reported off the coasts of Oregon and Washington during influxes of warm water masses to the north.

The overall California-Oregon-Washington stock size is estimated at 950 animals (Barlow 1997). The offshore stock feeds on squid as well as fish.

<u>Pacific white-sided dolphin</u> (*Lagenorhynchus obliquidens*)

Two forms of Pacific white-sided dolphins have been identified from genetic analyses: a northern form, which usually ranges from Point Conception to Washington and well offshore; and a southern form, which generally ranges from Point Conception to Mexico. Both forms have been found in the SCB, but whether this represents the two forms occupying this area at different times of the year or the two forms intermixing is unknown. Unfortunately, the two forms cannot be distinguished in the field (Barlow et al. 1997). At present, both stocks are managed as one.

The population of Pacific white-sided dolphins from Mexico to Washington has been estimated at 25,000 animals in California, Oregon, and Washington (Barlow 1997). These dolphins generally frequent waters along the Continental Borderland and slope as well as farther offshore. In the Channel Islands, they are often seen with humpback whales

(*Megaptera novaeangiliae*), which usually appear in summer and fall. Pacific white-sided dolphins feed primarily on fish.

Striped dolphin (*Stenella coeruleoalba*)

The striped dolphin is a pelagic species; that is, it roams far offshore beyond the continental slope some 100 nm seaward of land. The California population may be part of a greater population that extends well into the north Pacific and into Mexico and Central America. The estimated abundance of animals for California, Oregon, and Washington is 20,235 (Barlow 1997). The only reports of striped dolphins in Washington and Oregon have been of stranded specimens. The striped dolphin is widely distributed worldwide in tropical to warm temperate waters, often mingling with groups of spotted and spinner dolphins. The best-studied population exists in the eastern tropical Pacific, where incidental takes of these dolphins by the tuna purse seine fleet have been very high (Leatherwood et al. 1982; Leatherwood et al. 1987).

Northern right whale dolphin (*Lissodelphis borealis*)

The northern right whale dolphin is the only oceanic dolphin in the region that lacks a dorsal fin. It frequents waters along the Continental Borderland and slope. It prefers cool temperate waters, generally appearing in the region during La Niña events or in areas characterized by vigorous upwelling of colder waters, such as San Nicolas and San Miguel Islands. It is most common in winter and spring when the water is colder. In summer and fall, it can range as far north as Oregon and Washington. Its southern range limit is probably northern Baja California. The California population has been estimated at 13,705 animals for California, Oregon and Washington (Barlow 1997). Northern right whale dolphins feed on lanternfish, other mesopelagic fish, and squid.

Risso's dolphin (*Grampus griseus*)

Risso's dolphins are found throughout the region year-round in varying numbers. They are generally most abundant in the Santa Barbara Channel, particularly off the north shores of the four northern Channel Islands. They are often seen off the coast north of Point Conception. They are often found along the Continental Borderland, slope, and offshore. They range from at least northern Baja California to Washington. The stock size is approximately 16,400 animals in California, Oregon, and Washington (Forney et al. 2000). A distinctly separate stock appears to exist in the Gulf of Mexico and southern tip of Baja California.

Prior to the El Niño event of 1982 to 1983, Risso's dolphins were relatively uncommon in the region. Following this event, however, they were consistently seen in sizable numbers. At least one researcher has suggested that these animals may have occupied a niche vacated by short-finned pilot whales during the 1982 to 1983 El Niño event or that Risso's dolphins appeared during the El Niño event and competed so successfully that most of the pilot whales left the region.

Short-finned pilot whale (*Globicephala macrorhynchus*)

As discussed above, short-finned pilot whales disappeared during the 1982 to 1983 El Niño event. Over the past few years, however, progressively more individuals have been seen in the SCB, but they have not returned in their former numbers. At present, the

California, Oregon, and Washington population is estimated at 970 individuals (Barlow 1997).

Prior to the 1982 to 1983 El Niño event, short-finned pilot whales were reportedly resident off Santa Catalina Island (Dohl et al. 1980). They were also frequently seen in the Santa Barbara Channel, the Santa Cruz Basin, and off Santa Barbara Island. Short-finned pilot whales feed almost exclusively on squid, which may lend some credence to the theory that they were displaced by Risso's dolphins, which also prey heavily on squid.

<u>Orca or killer whale</u> (*Orcinus orca*)

Orcas found off the California coast are currently referred to as either the eastern North Pacific transient stock or the eastern North Pacific offshore stock (NMFS 1999). The transient stock travels as far north as Alaska and the east coast of Russia. Another stock of resident orcas exists in the waters of Puget Sound. Until recently, researchers believed that these animals stayed in the inland waters of the sound. Some individuals from the inland stock were identified in the company of transient orcas off the coast, however, clouding the issue of distinctive stocks. At present, the best estimate of the eastern North Pacific transient stock is 336 animals (NMFS 1999).

The eastern North Pacific offshore stock evidently does not mix with resident and transient stocks that overlap their range. This stock is found off the coast from California to Southeast Alaska. The best estimate of this stock size is 819 animals (NMFS 1999).

Orcas feed on fish and other marine mammals. In the Channel Islands, orcas have been observed feeding on gray whales (*Eschrichtius robustus*), Pacific harbor seals (*Phoca vitulina richardsi*), and California sea lions (*Zalophus californianus c.*). They have also been observed feeding on fish.

<u>Mysticetes – Right Whales</u>

Table 4-7. Cetaceans: Mysticetes - Right Whales in the project area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
Northern right whale *(Eubalaena glacialis)*	Not available for region	Protected, and strategic under MMPA. Endangered under ESA.	Extremely rare		Coastal

<u>Northern Right Whale</u> (*Eubalaena glacialis*)

Right whales are the most endangered of all the world's whales, having been hunted relentlessly in the seventeenth, eighteenth and nineteenth centuries. They are currently listed as endangered under the ESA, and depleted, protected, and strategic under the MMPA. The historic range of this species was thought to be the entire West coast, from the Bering Sea to Baja, Mexico. The pre-exploitation size of the stock was 11,000 animals. A current population estimate for the entire North Pacific is 100-200 animals (Kreitman and Schramm 1995), and it is doubted whether the species will remain extant. Recent sightings have ranged from Baja, Mexico, to Bristol Bay, AK, and there has been one sighting reported in the Santa Barbara Channel in 1981.

Northern right whales are baleen whales and feed primarily on the surface by skimming zooplankton-rich patches of surface water. They have occasionally been seen bottom feeding in shallow water (Kreitman and Schramm 1995).

Odontocetes: True Porpoises

Table 4-8. Cetaceans: Odontocetes - True Porpoises in the Project Area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat	Water Mass Preference
Dall's Porpoise *(Phocoenoids dalli)*	Stock size: 47,661	Protected under MMPA	Uncommon	Winter and spring	Shelf to well off-shore	Subtemperate waters
Harbor Porpoise *(Phocoena phocoena)*	Stock size: 5,732	Protected under	Uncommon		Shallow coastal	Subtemperate waters

Dall's porpoise (*Phocoenoides dalli*)

Dall's porpoises frequent waters from the Continental Borderland to well offshore. They prefer cooler temperate waters and are seldom seen if the sea surface temperature is above about 20 degrees C. They are most often seen in the SCB in winter and spring when the water is coldest. During La Niña years, they may roam as far south as northern Baja California (Barlow et al. 1997).

The California stock has been estimated at 116,016 animals for California, Oregon and Washington (1991-1996 average) (Barlow 1997). Dall's porpoises are among the fastest of small cetaceans, reportedly reaching speeds of up to 22 knots. They feed on fish and cephalopods, mainly at night.

Harbor porpoise (*Phocoena phocoena*)

Several stocks of harbor porpoises are recognized, more for management purposes than because of distinct geographic boundaries. A good part of the population frequents waters from about 91 meters into very shallow water. In central California, the population is estimated at 5,732 individuals (Forney 1999). Harbor porpoises feed on benthic and schooling fish and invertebrates.

Odontocetes: Sperm Whales

Table 4-9. Cetaceans: Odontocetes - Sperm Whales in the Project Area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
Sperm Whale *(Physeter macrcephalus)*	Stock size: 1,191	Protected, depleted, strategic under MMPA. Endangered under ESA	Rare	April to mid June and August to mid November	Deep sea
Pygmy sperm whale *(Kogia breviceps)*	Stock size: 3,145	Protected under MMPA	Uncommon		Deep sea, pelagic
Dwarf sperm whale *(Kogia simus)*	Stock size: 891	Protected under MMPA	Known from three strandings		Deep sea, pelagic

Sperm whale (*Physeter macrocephalus*)

Sperm whales are classified as endangered under the ESA, as a strategic stock under the MMPA, and depleted under the MMPA. For management purposes, the California-Oregon-Washington population is considered one stock, even though sperm whales are distributed as far north as Alaska and the Bering Sea. The California-Oregon-Washington stock is estimated at 1,191 animals (Barlow 1997).

Sperm whales inhabit deep ocean waters well offshore and have rarely been reported in the Santa Barbara Channel. At least two strandings of sperm whales have been reported for the northern Channel Islands. One specimen, which was ashore at San Miguel Island, was entangled in a nylon fishing net. Sperm whales appear to be most abundant from April to mid-June and from late August to mid-November although they have been reported year-round. At least some individuals are residents in California waters. Another resident population exists in the Gulf of California (Barlow et al. 1997; NMFS 1999). Sperm whales can dive to depths of at least 3,000 meters, staying down over an hour, so they may be under reported. They feed almost exclusively on squid.

California gray whale (*Eschrichtius robustus*)

Table 4-10. Cetaceans: Mysticetes - Gray Whales in the Project Area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
California gray whale *(Eschrichtius robustus)*	Population: 26,600	Protected under MMPA	Common	December through May; occasionally rest of year	Coastal

Of the large baleen whales, the California gray whale is the only species that has been delisted from the Federal Endangered Species List; this occurred in 1994. Its population now totals approximately 26,600 animals (Rugh et al. 1999).

Every year, the California gray whale migrates south from its winter feeding grounds in Alaska and the Bering Sea. Small numbers sometimes straggle from the Bering or Chukchi seas down the coast of Asia. In the past, such animals were considered a separate stock called the Korean or western Pacific stock (Leatherwood et al. 1982).

The vast majority of the California gray whale population appears in the SCB in December. However, individuals or small groups are often seen migrating south as early as October and November. Most of the southbound whales have passed the region by the end of February, but a few stragglers are sometimes seen later.

The northbound migration begins in February, and by the middle of the month, both south- and northbound animals may be seen in the SCB. The northbound migration generally continues into May, with mother-calf pairs becoming most abundant in April. In the SCB, California gray whales are believed to utilize three different general migration corridors. Interestingly, this is the time when transient orcas in large numbers are most often seen in the region. Attacks on gray whale calves and juveniles have been documented during this period. Gray whales have been reported for every month of the year, with occasional individuals lingering in the area over the summer.

Gray whales have been observed feeding in drifting patches of giant kelp offshore. Still, such feeding seems largely opportunistic, and the whales generally keep moving as they feed. Migrational feeding activities are more often observed during the northbound migration perhaps because more whales pass close to the mainland coast where they can be more readily observed.

Mysticetes - Rorquals

Table 4-11. Cetaceans: Mysticetes – Rorquals in the Project Area

Species	**Population or Stock Size**	**Protected Status**	**Relative Abundance**	**Seasonality**	**Normal Habitat**
Blue whale *(Balaenoptera musculus)*	Stock size:1,785 to 2,200	Protected, depleted and strategic under MMPA. Endangered under ESA	Common in Season	June to September; occasionally through November	Shelf and slope
Fin Whale *(Balaenoptera physalus)*	Stock size: 933	Protected, depleted and strategic under MMPA. Endangered under ESA	Uncommon	Summer, fall; possible year-round	Shelf and slope
Sei whale *(Balaenoptera borealis)*	Not available for region	Protected, depleted and strategic under MMPA. Endangered under ESA	Very Rare		
Bryde's whale *(Balaenoptera edeni)*	Stock size: 24	Protected under MMPA	Rare		Shelf and slope
Minke whale *(Balaenoptera acutorostrata)*	Stock size: 631	Protected and strategic under MMPA	Uncommon	Year-round; Most abundant in summer and fall	Coastal to slope
Humpback whale *(Megaptera novaeangliae)*	Stock size: 843	Protected, depleted and strategic under MMPA. Endangered under ESA	Common in Season	May to September	Shelf and slope

Blue whale (*Balaenoptera musculus*)

Blue whales are listed as endangered under the ESA. They are considered depleted, and the California-Mexico stock is listed as strategic under the MMPA.

A best estimate of this stock size is 1,940 animals, based on line transect aerial surveys and mark-recapture studies in which identification photographs are taken of individual whales over time (Forney et al. 2000). Based solely on photographic identifications, a more recent estimate of approximately 2,200 blue whales has been projected for the California-Mexico stock (Calambokidis et al. 2000).

Since 1989, blue whales have been appearing in numbers in the Santa Barbara Channel. Prior to that time, blue whale sightings were sporadic. Although blue whales have been reported at or near the region every month of the year, they generally arrive in early to mid-June and remain until August or September. Sometimes a number of individuals linger as late as November or even December. When blue whales are present in numbers in the Santa Barbara Channel, some 100 individuals may be in the area at one time. These animals seem to stay for several days or more than a week, then move on as others fill their place (Calambokidis et al. 2000). The Santa Barbara Channel has prodigious quantities of krill, mainly *Euphasia pacifica*, upon which the blue whales feed.

Blue whales also frequent the Gulf of the Farallones and areas offshore from Monterey Bay in the latter part of summer and early fall. Some individuals travel into Oregon and Washington, but the California-Mexico stock does not appear to journey to Alaska. In late fall and winter, the California-Mexico blue whale stock stays off the coast of Mexico and Central America. Some venture into the Gulf of California, while others travel to the oceanic islands and to the Costa Rica Dome. Little is known about the migration route from Central America and Mexico to California and back. From very limited observations and from a few satellite tags, it appears as though blue whales travel across wide expanses of deeper water offshore, then appear from west of San Nicolas Island across to

Santa Rosa and San Miguel Islands, entering and leaving the Santa Barbara Channel from the west.

Fin whale (*Balaenoptera physalus*)

Fin whales are listed as endangered under the ESA. They are considered depleted and strategic species under the MMPA. The California-Oregon-Washington management stock is considered strategic. Population estimates of fin whales vary, but based on 1991 and 1993 ship surveys, an estimate has been made of 1,236 fin whales for this stock (Barlow 1997). At least 148 fin whales have been photo-identified in the Gulf of California (Barlow et al. 1997). Whether these animals are resident or are part of the California-Oregon-Washington stock is unknown at this time. Fin whale abundance dwindles off the coasts of California and Oregon in winter and spring, while it increases during the same period in the Gulf of California. This may be coincidence, however. At least part of the population appears to spend winter and spring well off the southern California coast down to Mexico.

Fin whales are more cosmopolitan in their diet, feeding on krill, copepods, squid, and even small schooling fish. They have been observed in the Santa Barbara Channel near feeding aggregations of blue and humpback whales. These individuals were feeding on the same prey, *Euphausia pacifica*, a species of krill.

Sei whale (*Balaenoptera borealis*)

Sei whales are listed as endangered under the ESA and are considered depleted and strategic under the MMPA. Once commonly taken by whalers off the California coast in the 1950s and 1960s, sei whales are now quite rare. Several extensive aerial and ship surveys from 1991 through 1993 revealed only one confirmed sighting of a sei whale (Barlow et al. 1997).

Sei whales are rare south of California. Because of their overall scarcity, no population estimates are available for this species. Sei whales feed on much the same prey as do fin whales although sei whales also feed on amphipods.

Bryde's whale (*Balaenoptera edeni*)

Bryde's whales are common throughout the eastern tropical Pacific and are the most common balaenopterid in the Midriff region of the Gulf of California. There, 140 individuals have been photo-identified. During extensive ship and aerial surveys off California from 1991 through 1994, five possible observations of Bryde's whales were made. Bryde's whales are rare off California. The population is estimated at 12 individuals in California, Oregon, and Washington coastal waters (Barlow 1997). The minimum overall population in the eastern tropical Pacific has been estimated at 11,163 animals. Bryde's whales seem to prefer small schooling fish in their diet, including pilchards, anchovies, herring, and mackerel. They also feed on euphausiids.

Minke whale (*Balaenoptera acutorostrata*)

Minke whales are not listed under the ESA, nor are they considered depleted under the MMPA. The stock size is estimated at 631 individuals based on ship surveys in 1991, 1993, and 1996 (Barlow 1997). Minke whales occur year-round in the region, from relatively shallow coastal areas to shelves off the north shore of the four northern Channel Islands. They appear to be most abundant from late spring through late summer although they are never seen in large numbers. Feeding activities are generally associated with small schooling fish, although they may also eat euphasiids.

Humpback whale (*Megaptera novaeangliae*)

Humpback whales are endangered under the ESA and depleted and strategic under the MMPA. This particular stock is officially called the California-Oregon-Washington-Mexico stock. In reality, this stock ranges from at least Costa Rica to British Columbia. It does not mingle with the Alaska stock. Various estimates have been made for the California-Mexico stock. The most recent estimate, obtained by mark-recapture photo-identification methods, was 843 animals (Forney et al. 2000).

In winter, this stock congregates near oceanic islands off Mexico and Central America, with at least some individuals at the Costa Rica Dome. Humpback whales usually begin to appear in the region by late May and early June. They generally stay until August or September. Humpback whales may stay as late as November in the western reaches of the Santa Barbara Channel. Like the blue whales, the humpback whales travel into central California in summer and early fall, occupying much the same areas. Little is known about the movements of humpback whales between Central America and Mexico to the western coastal United States, but their movements may be similar to those of the blue whales.

Although humpback whales in the region feed primarily on krill, particularly *Euphausia pacifica*, they have also been observed feeding on northern anchovies (*Engraulis mordax*), Pacific sardines (*Sardinops sagax coeruleus*), and on various small fish and amphipods in drifting patches of giant kelp.

Pinnipeds

Historically, six species of pinnipeds have occurred in the northern Channel Islands. These include four members of the family Otaridae and two representatives of the family Phocidae. Two of the six species that have occurred in the Sanctuary are listed as threatened under the ESA.

Of the otarid seals, the California sea lion (*Zalophus californianus*) is the most abundant (Barlow et al. 1997). The Steller sea lion (*Eumetopias jubata*) had two rookeries on San Miguel Island, but these rookeries have not been occupied since the 1982 to 1983 El Niño event. The eastern stock of Steller sea lions is listed as threatened under the ESA. The northern fur seal (*Callorhinus ursinus*) has two rookeries on San Miguel Island. The Guadalupe fur seal (*Arctocephalus townsendi*) has been reported on San Nicolas and San Miguel Islands in very small numbers, usually from one to three individuals. A few strandings have occurred along the mainland coast (Hanni et al. 1997). The Guadalupe fur seal is listed as threatened under the ESA and CESA and is also fully protected under Fish and Game Code (Section 4700).

Of the phocid seals, the northern elephant seal (*Mirounga angustirostris*) is the most common, with rookeries at San Miguel, Santa Rosa, San Nicolas, and Santa Barbara Islands (Barlow et al. 1997). The Pacific harbor seal (*Phoca vitulina richardsi*) is common throughout the Channel Islands, with numerous haulout and rookery sites throughout the Channel Islands and along the mainland coast (Barlow et al. 1997). The ribbon seal (*Histriophoca fasciata*), an arctic species, has been reported twice in California (Daugherty 1972).

Otarids

Table 4-12. Pinnipeds: Otarids in the Project Area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat	Water Mass Preference
California sea lion *(Zalophus californianus c.)*	Stock Size: 167,000 to 188,000	Protected under MMPA	Common	Year round	Coastal	Tropical to temperate
Steller sea lion *(Eumetopias jubata)*	No stock size available	Protected and strategic under MMPA. Threatened under ESA.	Now extremely rare		Coastal	Subtemperate to subpolar
Northern fur seal *(Callorhinus ursinus)*	Stock size: 12,704	Protected under MMPA	Uncommon	May to November	Pelagic	Subtemperate to subpolar
Guadalupe fur seal *(Arctocephalus townsendi)*	Population: 6443	Protected, depleted, and strategic under MMPA. Threatened under ESA.	Extremely rare		Pelagic	Subtropical to temperate

California sea lion (*Zalophus californianus*)

The California sea lion consists of three subspecies: *Zalophus japonicus*, which occurred off Japan and is now thought to be extinct; *Zalophus wollebaeki*, found at the Galapagos Islands; and *Zalophus californianus californianus*, found from Baja California to British Columbia. The latter population is divided into three stocks. The range of the Gulf of California stock is as indicated by the name; the western Baja California stock extends from the southern tip of Baja California to the California border; and the U.S. stock ranges from California through Washington. The United States stock size has been estimated at 204,000 to 214,000 animals (Forney et al. 2000).

California sea lions have two main rookeries at the Channel Islands, one at San Miguel Island, the other at San Nicolas Island. Other rookeries exist at Santa Barbara and San Clemente islands. Several haul-out sites exist on Santa Cruz and Anacapa Islands. California sea lions are a coastal species, seldom venturing much past the Continental Borderland. Adult male California sea lions usually haul out from May into early August to defend their beach territories and breed. After mating, they head north, some reaching as far as British Columbia. The females linger with their pups, which are weaned at 4 to 10 months. Some continue to nurse for up to a year.

The females generally stay at the island haulout sites or near the mainland coast as far north as Monterey, as do the juveniles. A few adult males also linger in this region. California sea lions feed on small schooling fish and market squid (*Loligo opalescens*).

Steller sea lion (*Eumetopias jubata*)

NMFS manages the Steller or northern sea lion as two stocks. The eastern stock (which includes those in California waters) is listed as federally threatened. The Steller sea lion once had two rookeries at San Miguel Island. Since the El Niño event of 1982 to 1983, these rookeries have remained unoccupied. Only one sighting of a Steller sea lion has been reported at the Channel Islands since that time.

Northern fur seal (*Callorhinus ursinus*)

The northern or Alaskan fur seal has two rookeries of approximately 4,500 animals at San Miguel Island. These were reestablished in the late 1950s. The two rookeries have grown over the years to an estimated 4,300 animals (Barlow et al. 1997). At San Miguel Island, adult males usually arrive in May and stay through August. Some will stay as late as November, along with the females, although they will not maintain territories much beyond August. By November, most adults have left for the open ocean, where they will spend the next 7 to 8 months. Many pups will spend the next 22 months at sea after they have been weaned, finally returning to the rookeries where they were born. Northern fur seals are pelagic, frequenting offshore waters in search of fish and squid.

Guadalupe fur seal (*Arctocephalus townsendi*)

The Guadalupe fur seal is listed as threatened under the ESA. It is considered depleted under the MMPA and is also fully protected under Fish and Game Code (Section 4700).. The California-Mexico stock is considered strategic under the MMPA. The latest estimate of this population is 6,443 animals (Barlow et al. 1997), virtually all of which are found in Mexican waters at Guadalupe Island. A pup was born on San Miguel Island in 1997.

Phocids

Table 4-13. Pinnipeds: Phocids in the Project Area

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
Northern elephant seal (Mirounga *angustirostris)*	Stock size: 84,000	Protected under MMPA	Common in season	December to August	
Pacific harbor seal *(Phoca vitulina richardsi)*	Stock size: 30,293	Protected under MMPA	Common	Year round	Coastal
Ribbon seal *(Histriophoca*l *fasciata)*	Not applicable	Protected under MMPA	Extremely rare		

Northern elephant seal (*Mirounga angustirostris*)

The California population is considered a separate stock (Barlow et al. 1997). Northern elephant seals have two large rookeries on San Miguel and San Nicolas Islands. Smaller rookeries are found on Santa Barbara and Santa Rosa Islands. They have also been reported at Santa Cruz and Anacapa Islands but have not established rookeries there. The California stock was estimated at 84,000 animals in 1996 (Forney et al. 2000).

Northern elephant seals migrate to California twice from feeding grounds as far north as the Aleutian Islands and the Gulf of Alaska (for the males) and to areas off the Oregon coast (for the females). They migrate once to bear their young and breed, then a second time to molt. The pupping and breeding season extends from December through March. The molting season is between March and August. Males generally arrive later than the females. Northern elephant seals feed on deepwater organisms including bony fish, sharks, skates, rays, and squid, and octopus.

Pacific harbor seal (*Phoca vitulina richardsi*)

Two subspecies of harbor seals exist in the Pacific, *Phoca vitulina stejnegeri*, which is found in the western Pacific and in northern Japan and *Phoca vitulina richardsi*, which ranges from the Pribilof Islands in the Bering Sea to Baja California. The Pacific harbor seal is well-distributed in California, with 400 to 500 haulout sites along the mainland coast at river mouths, estuaries, beaches, offshore rocks, and islands, including San Francisco Bay, as well as at the Channel Islands. Harbor seals usually do not roam far from their haulout and rookery areas, although a few individuals may wander a few hundred kilometers. The best estimate of the California stock is 30,293 animals (Forney et al. 2000).

Harbor seals pup from February through May. Some pups have been reported in December and January at several rookeries. The most animals can be seen ashore at the Channel Islands during the molting season, which peaks from late May to early June. Harbor seals prey mostly on various species of bottom fish and octopi.

Carnivores: Mustelids

Table 4-14. Carnivores: Mustelids in the project area.

Species	Population or Stock Size	Protected Status	Relative Abundance	Seasonality	Normal Habitat
Southern sea otter *(Enhydra lutris nereis)*	Stock size: 2,090	Protected, depleted, and strategic under MMPA. Threatened under ESA.	Most abundant in spring	Year round	Coastal

Southern sea otter (*Enhydra lutris nereis*)

The southern sea otter is listed as threatened under the ESA and is considered depleted and strategic under the MMPA. ~~A total of 79 sea otters were counted in this area in 2000, and 65 were counted in 2001 (USFWS 2001). Offshore, about 17 sea otters have been reported at San Nicolas Island.~~ Southern sea otters eat certain mollusks, crustaceans, and echinoderms. Unlike Alaskan otters, they do not appear to eat fish.

The California sea otter population has increased steadily through most of the 1900s. Spring surveys of the otters indicate a growth rate of about 5 percent until 1995. Since 1995, the rate has declined by an average of 1.4 percent per year (USGS 2002b). In spring 1993, 2,239 California sea otters were counted throughout the State. The population decreased in both 2001 and 2002. The 2002 spring survey of 2,139 California sea otters reflects an overall decrease of 1.0 percent from the 2001 spring survey of 2,161 individuals (USGS 2002a). These declines were also seen in the local sea otter population. A total of 79 sea otters were counted in this area in 2000, and 65 were counted in 2001 (USFWS 2001). Offshore, about 17 sea otters have been reported at San Nicolas Island.

While no single year's survey result is indicative of a population change, researchers and managers are concerned at the overall slow rate of growth for the threatened California sea otter. Cooperative research efforts are ongoing to try to

understand why the otter's recovery has stalled since reaching 2,377 individuals in the 1995 survey.

The California sea otter's lineal range (distance along the 9-m [5-fathom] isobath between the northernmost and southernmost sightings) has also increased, although more slowly and erratically than the population size (data summarized by Riedman and Estes 1990). The direction of range expansion was predominately southward before 1981, but northward thereafter. Comparison between spring surveys conducted in 1983 and 1993 is sufficient to draw several conclusions. First, the population's range limits changed little during this 10-year period, even though large numbers of individuals accumulated near the range peripheries. Second, population density increased throughout this time, although rates of increase were lowest near the center of the range (USGS 2002b).

4.3.3.8 Threatened, Endangered and Special Status Species

The Federal Endangered Species Act (ESA) was passed to provide measures to conserve and recover listed species, thereby returning them to sustainable numbers no longer requiring the protection of ESA. The ESA contains a number of tools that are used by government agencies, local jurisdictions, user groups, and landowners to ensure that human activities are done in a way that avoids or minimizes the harmful effects of these activities.

NMFS is charged with the implementation of the ESA for marine and anadromous species, while the FWS implements programs and regulations for terrestrial and freshwater species. **An exception to this is the Southern sea otter, for which FWS is responsible for implementation of the ESA.** Section 7 of the ESA requires that Federal agencies, insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species. Likewise, the California Endangered Species Act policy is to conserve, protect, restore, and enhance any endangered or threatened species and its habitat. The ESA requires NMFS and the FWS to develop recovery plans for species added to the list of Threatened and Endangered (T&E) species. The Plans describe necessary conservation measures to ensure recovery of the species so that it becomes appropriate to remove the species from the T&E list.

The State also designates protection to one marine mammal under the California Endangered Species Act (CESA). Additionally, the California Fish and Game Code (Section 4700) designates several marine mammal species as "fully protected" (northern elephant seal, guadalupe fur seal, Pacific right whale, and southern sea otter). Fully protected mammals may not be taken or possessed at any time and no provision may be made to allow incidental take.

Under ESA, an endangered species is defined in the law as "any species which is in danger of extinction throughout all or a significant portion of its range." ~~Seven marine mammal~~ **Six whale** species occurring in California waters are listed as endangered~~; six whales and the southern sea otter~~. A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." The Steller sea lion**,** ~~and the~~ Guadalupe fur seal, **and Southern sea otter** are the only marine mammal species occurring in California waters that are listed as threatened. A candidate species is "any species being considered by the Secretary for listing as an endangered or threatened species, but not yet the subject of a proposed rule." There are no candidate marine mammal species found in California waters. The Guadalupe fur seal is listed under CESA as threatened.

All marine mammals are protected under the Federal Marine Mammal Protection Act (MMPA 1972, amended 1994) administered by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS). Additionally, NMFS and the FWS grant at-risk marine mammal stocks additional protection under the ESA with endangered, threatened, and depleted status designations. The MMPA also provides designations for at-risk marine mammal stocks. A species or a stock of a species is designated as depleted when it falls below its Optimum Sustainable Population (OSP) or, if the species is listed under ESA. Six whale species and the southern sea otter are considered depleted. The MMPA also lists a stock as strategic if: 1) it is listed as a T&E species under ESA; or 2) the stock is declining and likely to be listed as threatened under the ESA; or 3) the stock is listed as depleted under the MMPA; or 4) the stock has direct human-caused mortality which exceeds that stock's Potential Biological Removals (PBR) level. The term PBR is defined as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its OSP" (Barlow et al. 1995). As mandated in the 1994 amendments to the MMPA, NMFS develops estimates of PBR's for each marine mammal stock in U.S. waters.

NMFS issues permits through the Marine Mammal Authorization Program (MMAP) to provide an exception for commercial fishers from the general taking prohibitions of the MMPA. The owner of a vessel or non-vessel gear participating in a Category I or II fishery must obtain authorization from NMFS in order to lawfully incidentally take a marine mammal in a commercial fishery, while those participating in Category III fisheries may incidentally take marine mammals without registering for or receiving an authorization (NMFS/NOAA/OPR 2001). NMFS may also issue permits for the incidental, but not intentional, taking of marine mammals listed as T&E under ESA, (those species under NMFS's jurisdiction), if NMFS determines that incidental mortality and serious injury due to commercial fishing will have a negligible impact on the affected species or stock, a recovery plan for has been or is being developed, a monitoring program has been established (where required), vessels are registered, and a take reduction plan has been developed or is being developed (NMFS/NOAA/OPR 2001). With the 1994 amendments to the MMPA, intentional takes of marine mammals are now illegal except when imminently necessary in self-defense or to save the life of another person. Table 4-15 lists all species with special protection found in the project area.

Table 4-15. Species with special status under Federal or California State law found in the project area.

Common Name	Scientific Name	Federal/ State Status
Invertebrates		
Black Abalone	*Haliotis cracherodii*	Federally Proposed
White Abalone	*Haliotis sorenseni*	Federally Endangered
Birds		
Ashy storm-petrel	*Oceanodroma homochroa*	Federal Species of Concern, California Species of Special Concern
Black storm-petrel	*Oceanodroma melania*	California Species of Special Concern
California brown pelican	*Pelecanus occidentalis californicus*	Federally Endangered, State Endangered, California Fully Protected Species
Western snowy plover	*Charadrius alexandrinus nivosus*	Federally Threatened
California least tern	*Sterna antillarum brownii*	Federally Endangered, State Endangered, California Fully Protected Species
Double-crested cormorant	*Phalacrocorax auritus*	California Species of Special Concern
Rhinoceros auklet	*Cerorhinca monocerata*	California Species of Special Concern
Tufted puffin	*Fratercula cirrhata*	California Species of Special Concern
Xantus's murrelet	*Synthliboramphus hypoleucus*	Federal Species of Concern, California Species of Special Concern
Mammals*		
Northern right whale	*Eubalaena glacialis*	Federally Endangered, Strategic Stock, MMPA Depleted
Sperm Whale	*Physeter macrcephalus*	Federally Endangered, Strategic Stock, MMPA Depleted
Blue whale	*Balaenoptera musculus*	Federally Endangered, Strategic Stock, MMPA Depleted
Fin Whale	*Balaenoptera physalus*	Federally Endangered, Strategic Stock, MMPA Depleted
Sei whale	*Balaenoptera borealis*	Federally Endangered, Strategic Stock, MMPA Depleted
Humpback whale	*Megaptera novaeangliae*	Federally Endangered, Strategic Stock, MMPA Depleted
Harbor Porpoise	*Phocoena phocoena* (Cenral CA Stock)	Strategic Stock
Steller sea lion	*Eumetopias jubata*	Federally Threatened, Strategic Stock, MMPA Depleted
Guadalupe fur seal	*Arctocephalus townsendi*	Federally Threatened, State Threatened, Strategic Stock, California Fully Protected Species
Southern sea otter	*Enhydra lutris nereis*	Federally Threatened, Strategic Stock, MMPA Depleted, California Fully Protected Species

*All marine mammals are protected under the Marine Mammal Protection Act. Listed here are only those with additional State or Federal Protected Status.

4.4 Human Environment

The unique nature of the project area makes it a popular environment for both commercial and recreational uses. The proximity of the Channel Islands to the mainland make them uniquely accessible to the ports of Santa Barbara, Ventura, Port Hueneme, and Channel Islands Harbors. Human use of the project area is not limited to residents. Almost 20 percent of those who use California's coastal areas for recreation, for instance, are interstate or international (Resources Agency of California 1997).

This section contains information about human interactions with the project area ecosystems. Following a general, qualitative introduction to the activities taking place in the project area, a detailed, quantitative description of the baseline socioeconomic activities is presented. Activities are divided into the categories of aquaculture, commercial fish harvest, consumptive recreation (fishing and diving), and non-consumptive recreation (diving, whale watching, kayaking/island sightseeing, and sailing). Finally, a brief qualitative description of several remaining socioeconomic aspects is presented, including oil and gas.

Economic data presented in this section are modified from Chapter 1 and Appendix C of Leeworthy and Wiley, (2002), except where noted otherwise. Baseline estimates of commercial fishing activity and recreational activities and how they are connected to the local economies are presented in detail.

The economic models used to generate these baseline data are discussed in Chapter 5, as is the definition of the term “significant.” Briefly, the impact of an activity on an economy is deemed to be “significant” when it leads to a direct negative impact to the environment. Furthermore, the use of the term “impact” in this chapter generally is synonymous with “contribution,” e.g., the *impacts* of commercial fishing on the economy refers to the *contribution* of commercial fishing to the economy. This is contrast with following chapters, where “impact” refers to the effect of making changes to the baseline situation.

Project Areas and Economic Dependence on the project area

There are two fundamental definitions of the Economic Project Area. First is the area where the activities take place and second is the place where the economic and social impacts take place. For the first area, the definition is the area within the boundaries of the project area or six nautical miles seaward of the Channel Islands. Second is a seven-county area including Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego (Figure 4-9). All seven counties are impacted by commercial fishing activities and three counties (Santa Barbara, Ventura and Los Angeles) are impacted by recreational activities.

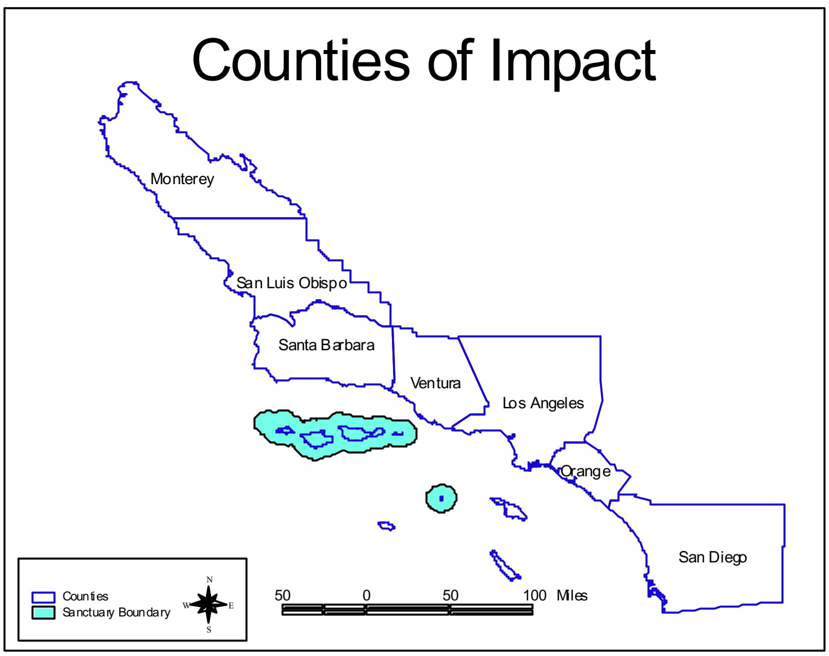

Figure 4-9. Socioeconomic counties of impact.

Population of Economic Project Area

The seven-county impact area had a 2000 population of over 16.98 million. Between 1990 and 2000, the population of the study area grew at a slower pace than the entire State of California or the U.S. (Table 4-16). The seven-county area had a much higher population density and higher poverty rate than either the State of California or the U.S. The higher population densities are mostly influenced by the inclusion of Los Angles and Orange counties, which have extremely high population densities, while the relatively high poverty rate is due to Los Angeles County. For per capita income, the seven-county area is higher than the U.S. but lower than the State of California. More extensive baseline population data for Santa Barbara and Ventura Counties can be found in Leeworthy and Wiley (2002).

Table 4-16. Selected Socioeconomic Measures for Description of Impact Areas

County	2000 Population	Population Change 1990-2000	Population Density[1]	1999 Per Capita Income	1997 Persons Below Poverty
Monterey	401,762	13.0%	120.9	$29,393	15.4%
San Luis Obispo	246,681	13.6%	74.7	$25,888	12.9%
Santa Barbara	399,347	8.0%	145.9	$30,218	14.6%
Ventura	753,197	12.6%	408.2	$29,639	10.3%
Los Angeles	9,519,338	7.4%	2,344.1	$28,276	20.5%
Orange	2,846,289	18.1%	3,607.5	$33,805	11.0%
San Diego	2,813,833	12.6%	670.0	$29,489	14.2%
All Counties	16,980,447	10.4%	838.2	$28,932	17.0%
California	33,871,648	13.6%	217.2	$29,856	16.0%
U.S.	281,421,906	13.1%	79.6	$28,546	13.3%

1. Number of people per square mile.

Source: U.S. Department of Commerce, Bureau of the Census, State and County QuickFacts. (http://quickfacts.census.gov)

Baseline relationships between local (county) economies and activities taking place in the project area

Table 4-17 shows annual personal income and employment by county for the seven-county impact area. Personal income is presented from two perspectives, by place of work and by place of residence. The distinction is made because many county economies are less dependent on sources of income from work related activities in the county, i.e., they derived their incomes from sources outside the county. Sources of incomes from outside the county include retirement pensions, dividends and interest from investments and from work in other counties (commuters). All seven counties in the impact areas have larger personal incomes by place of residence than by place of work.

Table 4-17. Personal Income and Employment by County 1999

County	Personal Income By Work Thousand's $	Personal Income By Residence Thousand's $	Employment Number Full and Part time Jobs
Monterey	$7,568,214	$10,927,131	218,719
San Luis Obispo	$3,818,023	$6,134,244	137,169
Santa Barbara	$7,678,915	$11,817,328	244,175
Ventura	$13,612,027	$22,083,017	390,770
Los Angeles	$211,861,080	$263,814,766	5,369,705
Orange	$70,341,257	$93,332,511	1,801,299
San Diego	$60,296,132	$83,183,395	1,664,791
Region Total	$375,175,648	$491,292,392	9,826,628

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Regional Information Management System (http://www.bea.gov)

Tables 4-18 and 4-19 show estimates for annual personal income and employment generated from each activity in each county. Directly under each estimate is the percent of the total personal income or employment that a given activity accounts for in each county's economy. Across all activities, the estimate of annual personal income impact of almost $172 million was less than four one-hundredths of one percent (a small fraction of one percent) of the entire seven-county area.

Table 4-18. Local/Regional Economic Dependence on the Sanctuary: Personal Income, 1999

County		Commercial Fishing	Consumptive Recreation	Total Consumptive Activities	Nonconsumptive Recreation[1]	All Activities
Monterey		$19,316,416	0	$19,316,416	0	$19,316,416
	%[2]	0.1768	0	0.1768	0	0.1768
San Luis Obispo		$121,758	0	$121,758	0	$121,758
	%	0.0020	0	0.0020	0	0.0020
Santa Barbara		$15,041,824	$1,872,105	$16,913,929	$1,928,484	$18,842,413
	%	0.1273	0.0158	0.1431	0.0163	0.1594
Ventura		$79,190,758	$22,430,489	$101,621,247	$4,022,904	$105,644,151
	%	0.3586	0.1016	0.4602	0.0182	0.4784
Los Angeles		$18,452,223	$384,325	$18,836,548	$69,366	$18,905,914
	%	0.0070	0.0001	0.0071	0.0000	0.0072
Orange		$271	0	$271	0	$271
	%	0.0000	0	0.0000	0	0.0000
San Diego		$9,521,785	0	$9,521,785	0	$9,521,785
	%	0.0114	0	0.0114	0	0.0114
All Counties		$141,645,036	$24,686,919	$166,331,955	$6,020,754	$172,352,709
	%	0.0288	0.0050	0.0339	0.0012	0.0351

1. Nonconsumptive recreation and All Activities are under estimated because no information was available for nonconsumptive recreation using private household boats to access the CINMS.
2. Percents are the percent of the total economy of each county, or for all counties, the percent of regional totals for all seven counties. The percents are all less than one percent or fractions of a percent.

Table 4-19. Local/Regional Economic Dependence on the Sanctuary: Employment, 1999

County		Commercial Fishing	Consumptive Recreation	Total Consumptive Activities	Nonconsumptive Recreation[1]	All Activities
Monterey		570	0	570	0	570
	%[2]	0.2606	0	0.2606	0	0.2606
San Luis Obispo		5	0	5	0	5
	%	0.0036	0	0.0036	0	0.0036
Santa Barbara		488	62	550	67	617
	%	0.1999	0.0254	0.2252	0.0274	0.2527
Ventura		2,410	579	2,989	110	3,099
	%	0.6167	0.1482	0.7649	0.0281	0.7930
Los Angeles		488	13	501	2	503
	%	0.0091	0.0002	0.0093	0.00004	0.0094
Orange		0	0	0	0	0
	%	0.0000	0	0.0000	0	0.0000
San Diego		94	0	94	0	94
	%	0.0056	0	0.0056	0	0.0056
All Counties		4,056	654	4,710	179	4,889
	%	0.0413	0.0067	0.0479	0.0018	0.0498

1. Non-consumptive recreation and All Activities are under estimated because no information was available for non-consumptive recreation using private household boats to access the CINMS.
2. Percents are the percent of the total economy of each county, or for all counties, the percent of regional totals for all seven counties. The percents are all less than one percent or fractions of a percent.

Table 4-18 shows the estimated economic contribution of each of the activities in the project area of each of the seven counties in the impact area. In 1999, all activities in the project area generated almost $172 million in personal income (Table 4-18). The estimated employment (number of full and part-time jobs) is about 4.9 thousand. These estimates include the multiplier impacts in each county. However, the estimates are underestimates due to a lack of information on the amount of non-consumptive recreation from private household boats. Including private household non-consumptive recreation would probably result in estimates between $180 and $190 million in annual income and between 5 and 5.5 thousand jobs that depend on the uses of the Sanctuary.

A review of Tables 4-18 and 4-19 will reveal that the inclusion of Orange County may bias the estimate of the impact of Project-Area activities on the economies of the seven-county Economic Study Area. Orange County has a relatively large economy and very little activity in the project area. However, each of the seven counties in the seven-county impact area is not significantly impacted by the activities in the project area. The highest impact is in Ventura County, which depends on a little over eight-tenths of one percent of its employment on activities in the project area.

Leeworthy and Wiley (2002) provide much greater detail on the populations and economies of Ventura and Santa Barbara counties. Generally, these areas can be characterized as growing, dynamic and diverse areas with both healthy and diverse economies.

4.4.1 Commercial Fishing

4.4.1.1 Aquaculture

Aquaculture is the practice of culturing, growing, and harvesting an aquatic species in a controlled setting. California has approximately 400 registered aquaculturists who raise products within intensive systems (enclosed, or on land) (Resources Agency of California 1997). Currently Ecomar is using several of the OCS oil and gas structures near the project area to raise aquacultural products, such as mussels and other invertebrates. The bulk of the statewide mussel production (85 percent) comes from offshore oil production platforms. No other approved aquaculture activities currently occur in the project area.

4.4.1.2 Commercial Fish Harvest

Commercial fishing (by nets, traps, and lines, diving, and other methods) occurs at various locations off the coast of Southern California, including portions of the Channel Islands, an extremely productive commercial fishing area. The nearshore waters along the coast from Ventura to Santa Barbara and the waters just off the Channel Islands contain giant kelp beds that provide habitats for numerous species. The majority of fish are caught within these areas. Fishery seasons are established and regulated by the Commission and regulated by the Department of Fish and Game.

The commercial harvest of kelp and other marine vegetation near the coastline is becoming a more established industry in Southern California. Live fish trapping (e.g., rockfish, sheephead, and other nearshore species) occurs primarily in the shallower waters near the coastlines of the Channel Islands. Hook and line fisheries catch a variety of species on hand lines, longlines, rod-and-reel, and trolled gear. The main species caught in hook and line fisheries is rockfish. Lobsters are fished in coastal waters since they are typically most abundant in rocky areas with kelp in depths of 100 feet (30 meters) or less. The waters off the majority of the Channel Islands are conducive to this habitat since they generally have an offshore shelf that extends gradually into deeper waters. Gillnets are not allowed within 3 nautical miles of the mainland coast, or within 1 nautical mile of the offshore islands in the project area. Commercial drift gillnetting for pelagic shark and swordfish occurs in the open waters throughout portions of the Channel Islands. This fishery, however, is only a small portion of the total industry in Southern California. The following section describes commercial fishing use of the project area.

<u>Giant Kelp</u>

Giant kelp was first harvested along the California coast during the early 1900s (Leet et al. 2001). Many harvesting companies operated from San Diego to Santa Barbara beginning in 1911. Those companies primarily extracted potash and acetone from kelp for use in manufacturing explosives during World War I. In the early 1920s, having lost the war demand, kelp harvesting virtually stopped. In the late 1920s, giant kelp was again harvested off California.

Giant kelp is now primarily harvested in California for extraction of alginates and other compounds and to supply food to several aquaculture companies for rearing abalones. It is also used for the herring-roe-on-kelp fishery in San Francisco Bay (Leet et al. 2001). Giant kelp is now one of California's most valuable living marine resources and in the mid-1980s supported an industry valued at more than $40 million a year. The annual harvest has varied from a high of 395,000 tons in 1918 to a low of less than 1,000 tons in the late 1920s. Such fluctuations are primarily due to climate and natural growth cycles, as well as market supply and demand. During the 10-year period 1970 to 1979,the harvest averaged nearly 157,000 tons, while from 1980 to 1989 the average harvest was only 80,400 tons. The harvest was low in the 1980s because the kelp forests were devastated by the 1982-1984 El Niño and accompanying storms, and by the 200-year storm that occurred in January 1988. In most areas, the beds of giant kelp recovered quickly, with the return of cooler, nutrient rich waters. Harvests in California increased to more than 130,000 tons in 1989 and to more than 150,000 tons in 1990.

In the project area, ISP Alginates is the only company harvesting giant kelp (baseline information below). During the 1990s, increasing international competition from Japan for the "low end," or less purified end of the sodium alginate market caused ISP Alginates to reduce harvests by about 50 percent (Leet et al. 2001). ISP Alginates anticipates California's harvest in this decade will be approximately 80,000 tons annually. The ISP Alginates Company uses specially designed vessels that have a cutting mechanism on the stern and a system to convey the kelp into the harvester bin. A propeller on the bow slowly pushes the harvester stern-first through the kelp bed, and the reciprocating blades mounted at the base of the conveyor are lowered to a depth of three feet into the kelp as harvesting begins. The cut kelp is gathered on the conveyor and deposited in the bin. These vessels can each collect up to 600 tons of kelp in one day and to facilitate its harvesting operations, the company conduct regular aerial surveys. Although the surface canopy can be harvested several times each year without damage to the kelp bed, regulations state that kelp may be cut no deeper than four feet beneath the surface. The survey information is used to direct harvesting vessels to mature areas of kelp canopy with sufficient density for harvesting.

Sea Urchin

One of the most important fisheries in California is the red sea urchin (*Strongylocentrotus franciscanus*). Red sea urchins are harvested by divers who generally use surface supplied air delivered through a hose (hooka gear) instead of self contained underwater breathing apparatus (SCUBA). Hooka gear consists of a low–pressure air compressor that feeds air through a hose to the diver's regulator. The hose is fed out from a reel so the diver has more maneuverability underwater. The urchins are gathered with a rake or hook and placed into large mesh bags which when full are lifted to the surface. Occasionally the bags, hoseline, and even the diver have to be freed from entangling kelp by cutting or breaking away stipes.

This red sea urchin fishery is relatively new, having developed over the last 30 years, and caters mainly to the Japanese export market (Leet et al. 2001). The gonads of both male and female urchin are the object of the fishery and are referred to as "roe "or "uni," in Japanese. Gonad quality depends on size, color, texture, and firmness. Algal food supply and the stage of gonadal development affect quality and price. The highest prices are garnered during the Japanese holidays around the new year. Sea urchins are collected by divers operating in nearshore waters. Divers check gonad quality and are size selective while fishing to ensure marketability. In the last few years the red urchin fishery has become fully exploited throughout its range in northern and southern California. The purple sea urchin (*S.purpuratus*),which occurs over the same geographical range, is harvested in California, but only on a limited basis.

The fishery in southern California began in 1971 as part of a National Marine Fisheries Service program to develop fisheries for underutilized marine species (Leet et al. 2001). The fishery was also seen as a way to curb sea urchins destructive grazing on giant kelp. There have been two periods of rapid fishery expansion in California. The first culminated in 1981 when landings peaked at 25 million pounds in southern California. Contributing to this rapid escalation of the fishery was a pool of fishermen and boats involved in the declining commercial abalone dive fishery. Sea urchin landings then decreased following the El Niño of 1982-1983, when warm water weakened or killed kelp, the primary food source for sea urchins. Catches did not recover until 1985-1986, helped in part by the strengthening of the Japanese yen relative to the U.S.dollar, favoring California fishermen and exporters. Prices for urchin from the south are typically higher than for urchins from northern California due to the longer market presence and consistently higher gonad quality of the former. The majority of sea urchin landings in southern California have come from the northern Channel Islands off of Santa Barbara, where large and accessible stocks once occurred (Leet et al. 2001).

Abalone

Three species of abalone were harvested commercially in California prior to 1997: red abalone (*Haliotis rufescens*), pink abalone (*H. corrugata*), and green abalone (*H. fulgens*). In 1997, the area from San Francisco Bay to the California-Mexican border was closed to commercial and recreational harvest of abalone. The Department determined that these species had suffered stock collapse due to overfishing. Prior to 1992, the commercial fishery for black abalone (*H. cracherodii*) was second in pounds landed to red abalone. However, this species suffered significant stock declines due to a condition called "Withering Foot Syndrome" and the fishery was closed in 1992 (Karpov et al. 2000). Currently, no commercial harvest of abalone is allowed in California.

Spiny Lobster

The commercial fishery for California spiny lobster (*Panulirus interruptus*) is among the species of highest commercial value. Since the late 1800s,there has been a commercial fishery for California spiny lobster in southern California. Commercial fishermen use box-like traps constructed of heavy wire mesh to capture spiny lobsters. Traps of other materials, such as plastic, are allowed, but wire traps remain the most popular. About 100 to 300 traps per fisherman is common, but some fish as many as 500 at the peak of the season. The traps are baited with whole or cut fish and weighted with bricks, cement, or steel to keep them on the seafloor. High-speed boats in the 20 to 40-foot size range are popular in this fishery, but everything from 15-foot skiffs to 50-foot fishing boats are used. Most trap boats are equipped with a davit and hydraulics to assist in pulling the traps (Leet et al. 2001)

Commercial lobster fishing occurs in shallow, rocky areas from Point Conception to the Mexican border and off the islands and banks of the project area. Sophisticated electronic equipment enables trappers to find suitable lobster habitat and relocate their traps there. Traps are fished along depth contours in waters less than 100 feet, or clustered around rocky outcrops on the bottom. At the beginning of the season the traps are usually very close to shore. By the end of the season they are in 100 to 300 feet of water. Seasonal landings in the 200,000 to 400,000 pound range rose following World War II and peaked in the 1949-1950 season, with a record 1.05 million pounds landed. A general decline followed for the next 25 years, reaching a low of 152,000 pounds in the 1974-1975 season. Landings started back up the next season, but remained between 400,000 and 500,000 pounds for nine consecutive seasons from 1979-1980 to 1987-1988. The next nine years the landings ranged from 600,000 to 800,000 pounds with a peak of 950,000 in the 1997-1998 season. Landings dropped back down after that. The peaks and valleys that have characterized this fishery are not unexpected in a fishery that is strongly influenced by the weather, El Niño and La Niña events, and the export market. About 90 percent of the legal lobsters taken in the commercial fishery weigh between 1.25 and 2.0 pounds, which produces the size of tail desired for the restaurant trade. Most of the harvest in recent years has been exported to Asian countries and France. However, depressed economies overseas have resulted in an effort to re establish domestic markets.

The range of California spiny lobster is from Monterey Bay south to Manzanillo, Mexico. Spiny lobsters are found primarily from the intertidal zone to 43 fathoms, in mussel beds and rocky areas with crevices, often in kelp beds. They generally hide in crevices and holes during the day and may be found on sandy bottoms at night. Giant kelp and other algal species, invertebrates, and small fish are preyed upon by lobster. Lobster are a part of the kelp forest community but their role is still undefined.

Prawn

The prawn fishery in the Project area includes trawl and trap fishing for spot prawns (*Pandalus platyceros*) and trawl fishing for ridgeback prawn (*Sicyonia ingentis*). Traditionally, a number of trawl boats fish year round for both ridgeback and spot prawns, targeting ridgeback prawns during the closed season for spot prawns and fishing for spot prawn during the ridgeback closure. Live spot prawns are now taken by trap and trawl vessels and account for 95 percent of these landings. Live ridgeback prawns account for 28 to 68 percent of these landings (Leet et al. 2001).

The trawler fleet operates from Fort Bragg south to the United States-Mexico border. Most vessels operate out of Monterey, Morro Bay, Santa Barbara, and Ventura, although a number of Washington-based vessels participate in this fishery during the fall and winter. The vessel length of the trawl fleet ranges from 28 to 85 feet with an average vessel length of 47 feet. Standard gear is a single-rig shrimp trawl of a semi-balloon, or Gulf Shrimp Act, design. Occasionally, double-rig or paired shrimp trawls are used. The body of the trawl net is typically composed of a single layer of 2.5-to three-inch meshes with a 36-square inch bycatch reduction device, and a minimum codend mesh size of 1.5 inches. Many fishermen prefer to use a double codend composed of two-to three-inch mesh. A variety of roller gear is added to the groundline of the trawl net, which keeps the ground off the bottom and prevents a variety of benthic invertebrates such as sea stars, sea fans, and anemones as well as rocks from being scooped into the net (Leet et al. 2001).

The trap fleet operates with boats ranging in size from 20 to 75 feet. Trap designs are limited either to plastic oval-shaped traps or to the more popular rectangular wire traps. Normally, a fisherman will set 25 to 50 traps attached to a single groundline (string) with anchors and buoys at both ends. Traps are set at depths of 600 to 1000 feet along submarine canyons or shelf breaks (Leet et al. 2001)

The fishery for spot prawns started nearly 69 years ago, when prawns were caught incidentally in octopus traps. In 1985, a trap fishery for spot prawn developed in the Southern California Bight. The trap fishery was concentrated around all of the Channel Islands. The rdigeback trawl fishery began in 1965. The landings and regulations of these three fisheries have varied tremendously since the inception of each fishery (Leet et al. 2001).

Nearshore Finfishes (Including Rockfishes and California Sheephead)

The Nearshore Fisheries Management portion of the MLMA of 1998 defined nearshore finfish species as rockfish (genus *Sebastes)*, California sheephead *(Semicossyphus pulcher*), greenlings (genus *Hexagrammos*), cabezon (*Scorpaenichthys marmoratus*), and other species found primarily in rocky reef or kelp habitat in nearshore waters. In the subsequent analyses in this document, the category *rockfish* includes all species of rockfish and cabezon. Since the early 1990's greater emphasis has been placed on identifying individual fish species harvested from this group and avoiding market categories that combine multiple species.

The development of the life/premium fishery in the late 1980's resulted in increasing commercial catches of many species of rockfish occupying the nearshore environment in and around kelp beds. The principal goal of this nontraditional fishery is to deliver fish live to the consumer in as timely a manner as possible. Trucks or vans equipped with aerated tanks are used to transport fish directly to buyers. These fishery has increased substantially since 1988, and it continues to supply communities with live and premium quality fishes. The impetus of this fishery is the unprecedented and increasing high price paid for live fish.

California sheephead range from the Gulf of California to Monterey, but are rarely found north of Point Conception. This species frequents rocky areas and kelp beds from the surface to 150 feet and deeper; females are usually found in shallower depths than the males. Typical food items are sea urchins, crabs, sand dollars, mussels, abalone and bryozoans (Feder et. al.,1974). While sheephead are most often observed in kelp beds and are known to venture farther from the bottom in the presence of kelp, the exact role that sheephead play, if any, in the kelp forest community is unclear (Feder et. al. 1974).

The live sheephead fishery uses baited wire traps to capture small females. These traps are similar in design as those used by crab harvesters. The basic design is a 3'x2'x1.5', double compartment trap with two entrance funnels. Traps are usually constructed of 2"x2" wire mesh. Since sheephead inhabit giant kelp beds, harvesters will set out traps adjacent to and within the kelp beds, along the southern California coast and around the Channel Islands.

Coastal Pelagic Species (Anchovy, Sardine, Mackerel, and squid)

The Coastal Pelagic Species (CPS or wetfish) category includes fisheries that generally employ purse seiners, and includes the Pacific sardine (*Sardinops sagax caeruleus*), northern anchovy (*Engraulis mordax*), and Pacific mackerel (*Scomber japonicus*), following closely the management classification of the Federal Coastal Pelagic Species Fisheries Management Plan.

Market Squid

For over 100 years market squid *(Loligo opalescen*s) has been harvested off the California coast from Monterey to San Pedro. The squid fishery has evolved into one of the largest fisheries in volume and economic value in California. Expanding global markets, especially in China and the Mediterranean, coupled with a decline in squid product from other parts of the world, has fueled a rapid expansion of the California squid fishery (Hastings and MacWilliams 1999)

Loligo opalescens ranges from British Columbia to Central Baja California (Recksiek and Frey 1978). Squid reproduction involves spawning within the water column, followed by the deposit of eggs upon the seafloor. The peak of the fishery targets the squid mating and egg laying behavior and occurs during fall and winter in Southern California. The majority of market squid harvest is centered in the northern Channel Islands region, mainly in the project area. In general, the harvest involves luring the animals to the surface with high wattage lamps, encircling them with purse seine nets and pumping and/or using brail nets to remove the squid from the water, finally storing them in a fish hold. On a good net set, tons of squid may be harvested. Squid are minimally processed, mainly in San Pedro, California, frozen and shipped around the world, predominately to markets in the Mediterranean and China (Hastings and MacWilliams 1999). Annual squid catches can be greatly influenced by El Niño events, as shown in the following quantitative section.

Squid play a vital role in the California Current ecosystem and serve as a major link in the food chain as both a predator and as prey. For example, squid prey items include planktonic crustacea, mainly euphausiids and copepods, but also fish, cephalopods, gastropods and polychaetes (Karpov and Cailliet 1978). In turn, several species of marine mammals from Risso's dolphins *(Grampus griseu*s) to California Sea Lions *(Zalophus californianu*s), a host of fish species, including many conomically important species like tuna and halibut, and a suite of seabirds all depend upon squid as a key food source (Hastings and MacWilliams 1999).

Flatfishes

The flatfish fisheries of interest include California halibut (*Paralichthys californicus*), starry flounder (*Platichthys stellatus*), sanddabs (*Citharichthys spp.*), and other flatfish. California halibut is caught by trawl and hook-and-line, and is an important fishery in the State. Both recreational and commercial anglers prize flatfish and they are targeted from boats, piers, and the shoreline. Major fluctuations in landings of some species seem to indicate inconsistent recruitment and availability.

Rock Crab

The rock crab fishery is made up of three species: the yellow rock crab (*Cancer anthonyi*), the brown rock crab (*C. antennarius*), and the red rock crab (*C. productus*). Approximately 95 percent of the landings in this fishery come from southern California, although rock crabs inhabit the nearshore waters of the entire State (Leet et al. 2001).

The three species are commonly found on sand near rocky reefs and within kelp beds around the holdfasts of kelp plants, where they prey on a variety of invertebrates. Rock crabs, along with several species of fish, are considered large predators associated with kelp but the exact nature of the role that crabs play in kelp forest community dynamics is unknown (Foster and Scheil 1985).

Rock crabs are harvested using baited traps. The traps are set and buoyed either singly or as part of a string (two or more traps tied together). Trap designs and materials vary but most employ single chamber, rectangular traps of 2X4– or 2X2–inch wire mesh. Once set, the traps are left in place for 48 to 96 hours before being checked. A single harvester may use 200 or more traps at one time. Fishermen tend to replace their traps in the same location until fishing in that area diminishes. This creates pathways in the kelp canopy because of the passage of the boats along the same course. The kelp that is cut loose will either fall to the bottom to be eaten by sea urchins and other herbivores, drift out to sea, or become part of the beach litter, or a combination of these events may occur.

Sea Cucumber

Most of the catch is taken in southern California waters, with divers almost exclusively harvesting the warty sea cucumber (*Parastichopus parvimensis*) while trawlers primarily take the California sea cucumber (*P. californicus*). Divers take their sea cucumbers as far south as San Diego, but most of the catch is taken off the four northern Channel Islands in depths of 6-20 fm (Leet et al. 2001).

Most of the California and warty sea cucumber product is shipped overseas to Hong Kong, Taiwan, China, and Korea. Chinese markets within the United States also purchase a portion of California 's sea cucumber catch. The majority are boiled, dried, and salted before export, while lesser quantities are marketed as a frozen, pickled, or live product. The processed sea cucumbers can sell wholesale for up to $20 per pound. In Asia, sea cucumbers are claimed to have a variety of beneficial medicinal or health enhancing properties, including lowering high blood pressure, aiding proper digestive function, and curing impotency. Studies of the biomedical properties of various sea cucumber chemical extracts, such as saponins, and chondroiton sulfates, are being conducted by western medical researchers investigating the efficacy of these substances for pharmaceutical products (Leet et al. 2001).

Tuna

The tuna category includes several highly migratory species, including albacore, bluefin tuna, yellowfin tuna, and bonito. Tuna are caught commercially with hook and line gear. Trolling or jig vessels take the majority of albacore, with a small portion using live bait. Additionally, the wetfish fleet may target some tuna species during the summer. In some year, they may catch significant amounts of albacore (Leet et al. 2001). Historically, commercial effort for albacore has fluctuated over the past 100 years, based primarily on market and oceanic conditions.

A variety of regulations are currently used to manage fisheries in the project area. These include total prohibitions on the take of certain species, seasonal closures, and other regulations. Table 4-19A summarizes some of the major closures currently in place. This table is not a complete reproduction of fishing regulations and is included to show the level of protection currently provided to certain species or species groups.

Table 4-19A. General summary of existing commercial fishing prohibitions in the project area. Note that this is not a complete reproduction of all fishing regulations (e.g., size limits and gear restrictions) and should not be used for legal compliance.

SPECIES	GEAR TYPE	SEASON	REGULATIONS
Abalone			Abalone may not be taken, possessed, or landed for commercial purposes.
All Species – Marine Resources Protection Zone	Gill Nets		Prohibited in waters less than 70 fathoms or within 1 nautical mile, whichever is less, around the Channel Islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, San Nicolas, Santa Barbara, Santa Catalina, and San Clemente).
Rockfish	Gill Nets and Trammel Nets		Use Prohibited in State waters for the take of rockfish.
Rockfish & Lingcod	Gill Nets and Trammel Nets		Prohibited in waters less than 70 fathoms in depth south of Point Sal, except drift and set gill nets shall not be used in waters less than 100 fathoms in depth at Sixty-Mile Bank. Prohibition on the take of rockfish in State waters applies.
Swordfish & Shark	Drift Gill Nets	Feb 1 to April 30	Closed Season
Swordfish & Shark	Drift Gill Nets	May 1 to Aug 14	Use prohibited within 75 nautical miles of the mainland coast between the westerly extension of the CA-OR boundary and the westerly extension of the US-Mexico boundary.
Swordfish & Shark	Drift Gill Nets	May 1 to July 31	Use prohibited within 6 nautical miles westerly, northerly, and easterly of the shoreline of San Miguel Island between a line extending 6 nautical miles west from Point Bennett and a line extending 6 nautical miles east from Cardwell Point and within 6 nautical miles westerly, northerly, and easterly of the shoreline of Santa Rosa Island between a line extending 6 nautical miles west from Sandy Point and a line extending 6 nautical miles east from Skunk Point.
Swordfish & Shark	Drift Gill Nets	May 1 to July 31	Use prohibited within 10 nautical miles westerly, southerly, and easterly of the shoreline of San Miguel Island between a line extending 10 nautical miles west from Point Bennett and a line extending 10 nautical miles east from Cardwell Point and within 10 nautical miles westerly, southerly, and easterly of the shoreline of Santa Rosa Island between a line extending 10 nautical miles west from Sandy Point and a line extending 10 nautical miles east from Skunk Point.
Swordfish & Shark	Drift Gill Nets	Dec 15 to Jan 31	Use prohibited in ocean waters within 25 nautical miles of the mainland coast.
Squid	Round Haul Nets	Weekend Closure	Season open from noon Sunday until noon Friday each week.
Yellowtail, barracuda, white seabass, salmon, steelhead, striped bass, and shad	Round Haul Nets		Use prohibited to take these species.
All Species	Trawl Nets		Prohibited out to 3 miles offshore mainland coast. (Except California halibut trawl grounds, 1-3 miles offshore between Pt. Arguello and Pt. Mugu). Special restrictions apply.
Halibut	Trawl Nets	March 14 - June 16	Closed Season - California Halibut Trawl Grounds. Use prohibited in waters between one and three nautical miles from the mainland shore between Pt. Arguello and Pt. Mugu.
Pink Shrimp	Trawl Nets	November 1 - March 31	Closed Season for Pacific Ocean Shrimp.
Shelf Groundfish			All fishing that may impact groundfish species is prohibited between 20 and 150 fathoms in depth. Other specific regulations apply.
Prawns & Shrimp	Traps		Use prohibited from Point Conception south to the Mexican border inside 50 fathoms depth.
Sea urchin		Various Closures - April through October	Various daily and weekly closures are in effect during this time period.
Lobster	Traps	First Wed. after March 15th to 1st Wed. in October	Closed Season

Economic Overview of Commercial Activities

Table 4-20 shows the annual ex-vessel value of the commercial fisheries in the project area for years 1999 and for the average of years 1996-1999. In 1999, the top 14 species/species groups accounted for 99.7 percent of the commercial landings from the project area and for the years 1996-1999, the top 14 accounted for 98.69 percent of the commercial landings from the project area. Abalone fishing was halted in 1997, so for the years 1996-1999, the top 14, excluding abalone accounted for 99.21 percent of the value of commercial landings.

The top 14 species/species groups are included in the classification and subsequent analyses (see later chapters) of Commercial Fisheries, along with kelp. Kelp was treated differently because only one company harvests it, ISP Alginates located in San Diego, California. Harvested value equivalent to ex-vessel value was not available. Instead, ISP Alginates supplied the processed value of kelp (1996-1999 average of $5,991,367). A separate economic impact model was created for kelp with the help of Dale Glantz of ISP Alginates. All the economic impact from kelp takes place in San Diego County where it is landed and processed.

Due to the trends in project area catch and value from 1988-1999, Leeworthy and Wiley (2002) used the average of years 1996-1999 as the most representative estimate for extrapolating future impacts (Chapter 5). The trends in catch, value of catch and prices for the project area and for the State of California are included in Leeworthy and Wiley (2002). One can see in Table 4-20 that squid is the dominant fishery in the project area as well as the State of California. Squid catch, however, is sensitive to El Niño events. In 1998, squid catch plummeted then rebounded to a record catch in 1999. Spatial distributions of the fisheries value data for kelp, squid, wetfish and tuna are shown in Figures 4-10, 4-11, 4-12, and 4-13, respectively. Landing data for each fishery, separated according to port, can be found in Leeworthy and Wiley (2002).

Table 4-20. Commercial Fishing Ex-Vessel Value for the CDFG 22 Block Definition of the Sanctuary

Species/Species Group	1999 Value $	Percent	Avg. 1996-1999 Value $	Percent	Rank 1999	Rank 1996-1999
Squid	26,558,813	72.31	13,046,664	58.21	1	1
Urchins	5,963,876	16.24	5,265,233	23.49	2	2
Spiny Lobster	952,991	2.59	922,098	4.11	3	3
Prawn	743,159	2.02	703,186	3.14	4	4
Rockfishes	549,446	1.50	549,319	2.45	5	5
Anchovy & Sardines [1]	548,944	1.49	234,367	1.05	6	9
Flatfish	324,685	0.88	183,871	0.82	7	10
Crab	313,289	0.85	343,664	1.53	8	6
Sea Cucumbers	267,842	0.73	167,700	0.75	9	12
CA Sheepshead	153,147	0.42	235,928	1.05	10	7
Sculpin&Bass	88,547	0.24	60,327	0.27	11	14
Mackerel [1]	59,921	0.16	67,119	0.30	12	13
Tuna	53,694	0.15	305,665	1.36	13	8
Shark	41,638	0.11	34,751	0.16	14	16
total included in analyses	**36,619,992**	**99.70**	**22,119,892**	**98.69**		
Abalone	47	0.00	178,027	0.79	25	11
Swordfish	21,472	0.06	39,090	0.17	17	15
Roundfish	37,318	0.10	33,262	0.15	15	17
Other	23,728	0.06	22,990	0.10	16	18
Yellowtail	14,832	0.04	6,891	0.03	18	19
Shrimp	1,057	0.00	5,813	0.03	22	20
Mussels and Snails	7,745	0.02	4,694	0.02	19	21
Salmon	1,407	0.00	1,411	0.01	21	22
Rays & Skates	2,283	0.01	1,164	0.01	20	23
Surf Perch	447	0.00	695	0.00	23	24
Grenadiers	0	0.00	211	0.00	26	25
Octopus	169	0.00	196	0.00	24	26
total not included in analyses	**110,505**	**0.30**	**294,444**	**1.31**		
Total All Species [2]	**36,730,497**	**100.00**	**22,414,336**	**100.00**		
Total, excluding Abalone	**36,730,450**	**99.99987**	**22,236,309**	**99.21**		

1. Anchovy & Sardine and Mackerel are combined in the Wetfish map.
2. Kelp is not included here because it is measured differently. The 1996-1999 average for Kelp used in our analysis is $5,991,367 and represents the processed value of kelp from ISP Alginates.

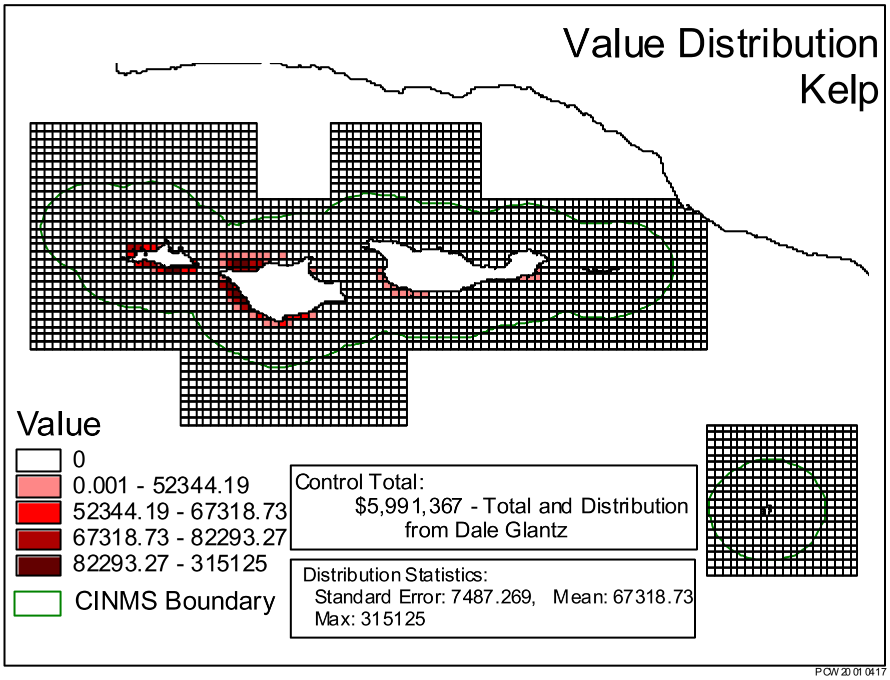

Figure 4-10. Spatial distribution of kelp value in the project area.

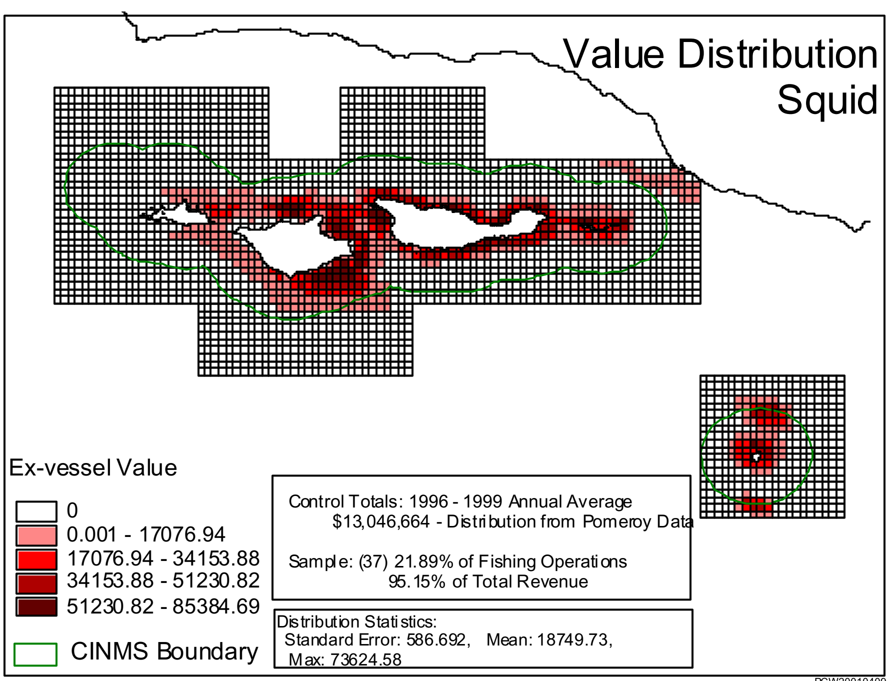

Figure 4-11. Spatial distribution of Squid Value in the project area.

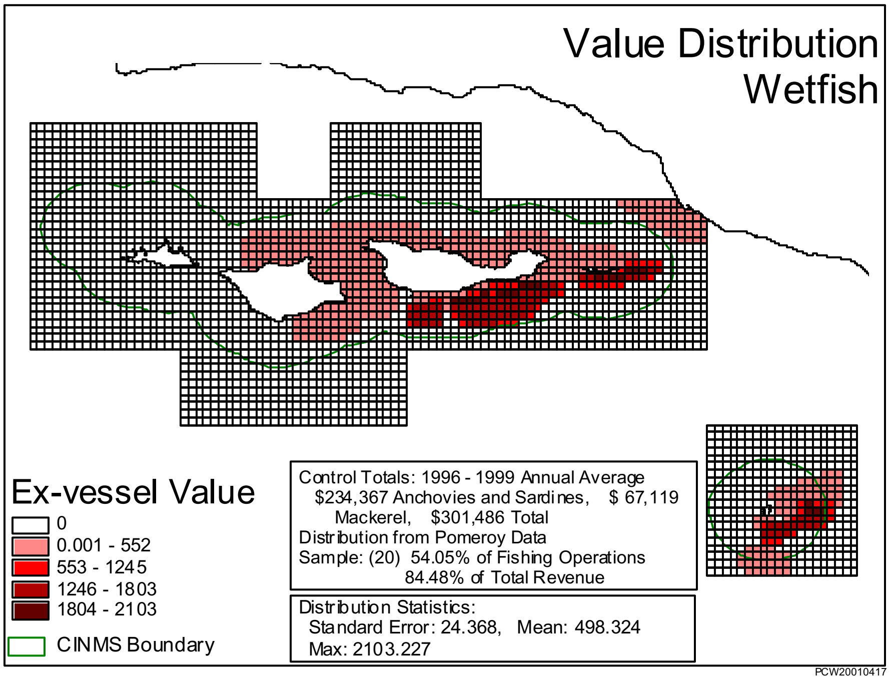

Figure 4-12. Spatial distribution of wetfish value in the project area.

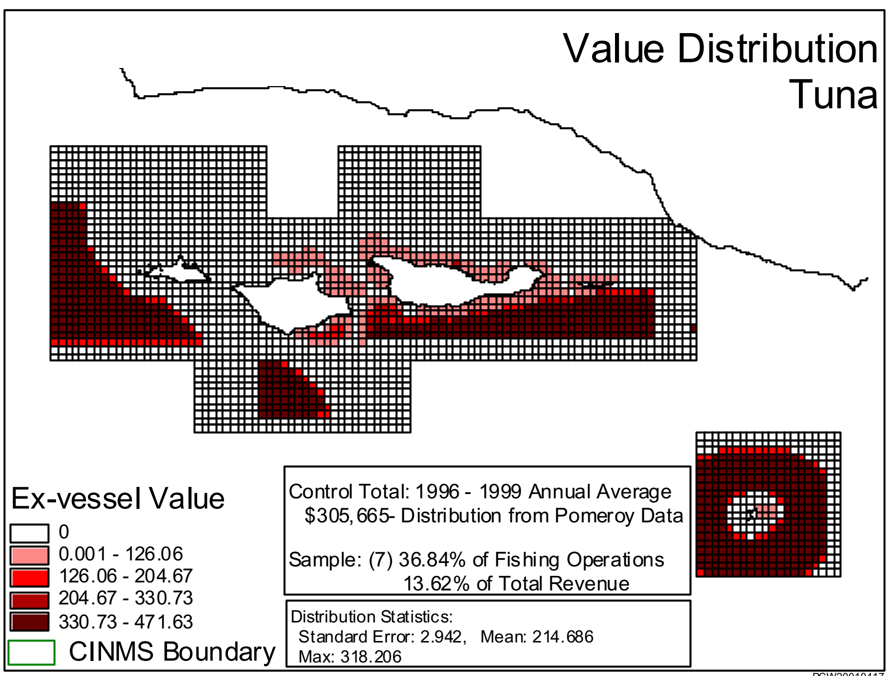

Figure 4-13. Spatial distribution of tuna value in the project area.

Baseline 1996-1999 Economic Impacts.

Table 4-21 summarizes the baseline 1996-1999 annual averages for total income and employment generated from commercial fishing and kelp from the project area. It is especially important to note the differences in Table 4-21 from those presented earlier in Table 4-18. As with the average annual ex-vessel value of landings, the annual average total income and employment impacts for years 1996-1999 are much smaller than the impacts for 1999. Again, most of the difference is explained by the record year for squid in 1999.

Table 4-21. Economic Impact of Commercial Fishing and Kelp Harvesting: Baseline Annual Average 1996-1999

County	Total Income	Employment
Monterey	$9,488,934	280
San Luis Obispo	$113,547	4
Santa Barbara	$13,352,514	433
Ventura	$40,397,319	1,229
Los Angeles	$10,043,552	266
Orange	$583	0
San Diego	$9,517,101	93
All Counties	$82,913,552	2,307

Socioeconomic Profiles of Fishermen

Leeworthy and Wiley (2002) surveyed two separate samples of fishermen. The first sample is sometimes referred to as the Pomeroy Sample and includes fishermen in the squid/wetfish fishery. The second sample is sometimes referred to as the Barilotti Sample and includes fishermen in all other fisheries, except squid and wetfish. It is important to note that both samples can be characterized as being involved in multi-species fisheries. Tables 4-22, 4-23, and 4-24 provide socioeconomic profiles for both samples of fishermen and demonstrate that each sample depends on multiple species. Often the multiple species dependency is seasonal and important in supplying income flows over the course of a year. Small percentages of dependency on a particular species/species group may involve a week or a month of income at a time when the opportunity to catch the main species/species groups fished are not available and participation in other fisheries are the only source of income. This kind of dependency is taken into account in subsequent analyses. Here a baseline profile of fishermen of the project area is provided, and compared with some profiles of fishermen obtained from a study of Tri-County fishermen (i.e., Santa Barbara, Ventura and San Luis Obispo counties).

Table 4-22. Commercial Fishing: Multi-Species Fishery, Barilotti Sample

	N	Mean	Range
Number of Species/Species Groups Caught in CINMS	56	2.59	1 - 13
	Number	**Percent**	**Cumulative Percent**
	1	48.2	48.2
	2	25.0	73.2
	3 - 4	12.5	85.7
	5	5.4	91.1
	GT 5	8.9	100.0
Number of Species/Species Groups Caught Anywhere	N	Mean	Range
	58	3.41	1 - 14
	Number	Percent	Cumulative Percent
	1	39.7	39.7
	2	22.4	62.1
	3 - 4	12.0	74.1
	5	6.9	81.0
	GT 5	19.0	100.0

Table 4-23. Socioeconomic Profiles: Commercial Fishermen, Barilotti Sample

	N	Mean	Range
EXPERIENCE			
Years Commercial Fishing	58	20.16	8 - 32
Years Fishing IN CINMS	57	19.11	4 - 32
AGE	58	44.83	30 - 64
EDUCATION			
Years of Schooling	57	12.89	0 - 17
DEPENDENCY ON FISHING			
Percent of 1999 Income from Fishing	57	90.02	10 - 100
Percent of 1999 Household Income from Fishing	57	83.49	10 - 100
Percent of Fishing Outside CINMS	55	17.71	0 - 97
Percent of 1999 Fishing Revenue from CINMS			
Urchin	40	73.76	0 - 100
Spiny Lobster	10	58.39	0 - 100
Sea Cucumbers	13	71.88	0 - 100
Rockfish	17	20.42	0 - 100
Crab	17	35.85	0 - 100
Flatfish	11	10.47	0 - 52.16
CA Sheepshead	16	49.27	0 - 100
Sculpin & Bass	6	10.02	0 - 37.74
Shark	8	4.72	0 - 18.93
Other (those not listed above)	17	52.92	0 - 100
All Species/Species Groups	**57**	**71.46**	**2.8 - 100**
PEOPLE DIRECTLY EMPLOYED AND FAMILY MEMBERS SUPPORTED			
Number of Crew	55	1.36	0 - 11
Number of Crew with Own Fishing Licenses	55	1.29	0 - 11
Number of Family Members Supported by Captains/Owners, not including self	58	2.1	0 - 5
OWNERSHIP/INVESTMENT			
Boat Ownership (Percent Yes)	88.3		
Replacement Value of Boat	57	120,930	0 - 1,400,000
Replacement Value of Electronic Equipment	53	11,126	0 - 90,000
Replacement Value of Fishing/Diving Gear	54	16,231	1,000 - 110,000
Replacement Value Boat, including Equipment and Gear	50	128,104	1,500 - 660,000

Table 4-23. (Continued)

RESIDENCE/MAIN LANDING PORT	Percent
State	
California	100
City	
Arroyo Grande	1.8
Atascadero	3.5
Carpenteria	5.3
Goleta	3.5
La Conchita	1.8
Morro Bay	1.8
Newbury Park	1.8
Ojai	1.8
Oxnard	7.0
Oak View	1.8
San Pedro	1.8
Santa Barbara	52.6
Simi Valley	1.8
Tarzana	1.8
Ventura	12.3
Main Landing Port	
Channel Islands Harbor	13.8
Santa Barbara	63.8
San Pedro	1.7
Ventura Harbor	15.5
Multiple	5.1

Table 4-24. Socioeconomic Profiles: Squid/Wetfish Fishermen, Pomeroy Sample

	Purse Seine Boats		Light Boats	
EXPERIENCE	Mean	Range	Mean	Range
Years Commercial Fishing	26.28	9 - 56	19.12	8 - 28
Years Fishing in CINMS	17.00	4 - 45	13.62	6 - 27
AGE	44.18	29 - 61	37.00	26 - 44
EDUCATION				
Years of Schooling	11.78	0 - 16	12.56	10 - 15.5
DEPENDENCY ON FISHING				
Percent of 1999 Income				
From CINMS Squid	70.34	32 - 100	86.90	65 - 100
From Other CINMS Fisheries	3.88	0 - 25	6.62	0 - 25
From Fisheries Outside CINMS	23.33	0 - 60	5.84	0 - 27
From Non Fishing Work	0.38	0 - 10	0.00	0
From Investments	2.07	0 - 17	0.63	0 - 5
Percent of Average Annual 1996-99 Fishing Revenue1				
Squid fishing in CINMS/All Squid Fishing	71.07	25.39 - 98.47	14.63	0.96 - 44.44
Wetfish in CINMS/All Wetfish Fishing	22.10	0 - 100	3.77	0 - 15.08
Tuna in CINMS/All Tuna Fishing	3.79	0 - 100	14.59	0 - 25.73
Other Finfish in CINMS/All Other Finfishing	6.90	0 - 100	38.67	0 - 70.72
Shellfish in CINMS/All Shellfishing	3.45	0 - 100	41.97	0 - 100
All CINMS Fishing/All Fishing	60.93	11.95 - 94.60	13.71	5.20 - 22.29
People Directly Employed and Family Members Supported				
Number of Crew on Main Vessel	5.00	3 - 9	0.875	0 - 2
Number of Relief Skippers	0.31	0 - 1	0.375	0 - 1
Number of Captain/Owners Family Members, including self	3.64	1 - 6	2.75	1 - 5
Number of Family Members Supported by Crew, including crew	18.54	3 - 54	2.375	0 - 8
Total Supported, except Relief Skipper Family	22.12	5 - 59	5.5	2 - 12
OWNERSHIP/INVESTMENT				
Boat Ownership	***Percent***			
Sole Owner	27.6		25.0	
Owns with Other Family Member	44.8		12.5	
Owns with Partner	13.8		50.0	
Market owns	3.4		0.0	
Other owns	10.3		12.5	
	Mean	Range	Mean	Range
Length of Ownership	19.04	4 - 37	11.19	0 - 23
Number of Boats Owned	0.86	0 - 3	0.88	0 - 3
Replacement Value of Main Boat, including all equipment	$778,793	75,000 - 2,000,000	$210,000	70,000 - 485,000
Replacement Value of All boats, including all equipment	$917,931	275,000 - 2,800,000	$272,500	120,000 - 600,000
RESIDENCE/HOME PORT/MAIN LANDING PORT	Percent		Percent	
Residence				
State				
California	93.1		100	
Washington	6.9		0	

The commercial fishermen other than squid/wetfish or the Barilotti Sample included 59 fishermen. The squid/wetfish or Pomeroy Sample included 29 purse seine boats and 8 light boats. Profiles of purse seine boats and light boats are presented separately. Not every fisherman supplied complete information so sample size (N) or the number responding to each item is reported in Tables 4-22, 4-23, 4-24. Measurements included: 1) Experience (Years of Commercial Fishing and Years Commercial Fishing in the project area and Age of the fisherman interviewed), 2) Education (Years of Schooling of the fisherman interviewed), 3) Dependency on Fishing (Percent of Income from Fishing, Percent of Fishing Revenue from project area and Number of Crew and Family Members Supported by directly by the fishing operation), 4) Ownership/Investment (Boat Ownership and Replacement Value of Boats and Equipment), 5) Residence (State and City) and 6) Ports Used (Home Port, Main tie-up Port, and Main Landing Port). More detail was available from the squid/wetfish fishermen (Pomeroy Sample) than the other commercial fishermen (Barilotti Sample).

Although the samples of commercial fishermen accounted for 79 percent of the annual total ex-vessel value of catch from the project area, they represent only 13 percent of the total number of fishermen reporting catch in the project area. In 1999, there were 737 fishing operations reporting some catch from the project area. Nineteen (19) percent accounted for 82 percent of the annual total ex-vessel value, with each of these operations receiving at least $50,000 per year in ex-vessel value (141 operations). Almost 64 percent of fishing operations (469) received less than $20,000 per year and accounted for only about 6 percent of annual total ex-vessel value from the project area, and 23 percent (170 operations) earned less than $1,000 per year, which was 0.20 percent of the annual total ex-vessel value from the project area (Leeworthy and Wiley 2002).

Tri-County Fishermen

Additional baseline data are presented for Tri-Counties fishermen (Table 4-25). No difference was found between the two study samples for Experience, Age, or Number of Crew. The Tri-County sample had higher levels of education, a higher percentage of boat ownership, a lower proportion living in Santa Barbara and also reporting Santa Barbara as their Home Port, and our sample was less dependent on fishing for their income.

Table 4-25. Comparative Profiles: Tri-County Fishermen [1]

	All Tri-County Fishermen [2]	Tri-County Fishermen that Fish in CINMS	Tri-County Fishermen NOAA Samples [3]
EXPERIENCE			
Years Commercial Fishing	Percent	Percent	Percent
1 to 10	26.1	27.4	6.3
11 to 20	32.2	39.0	36.1
21 to 30	29.8	26.3	41.3
31 to 40	6.2	6.3	6.3
Greater than 40	5.7	1.0	0.0
N	245	95	63
Mean	N/A	17.53	20.75
AGE	Percent	Percent	Percent
25 to 29	3.0	5.4	0.0
30 to 39	27.2	36.9	25.0
40 to 49	37.5	36.9	43.8
50 to 59	20.4	15.3	29.6
60 to 69	7.3	3.3	1.6
Greater than 69	4.8	2.2	0.0
N	235	92	60
Mean	N/A	42.98	45.28
EDUCATION			
Years of Schooling	Percent	Percent	Percent
Less than 12	8.1	7.6	12.7
12	24.6	21.7	30.2
Greater than 12	67.3	70.7	57.1
N	236	92	63
DEPENDENCY ON FISHING			
Percent of Income from Fishing	Percent	Percent	Percent
0 to 19	19.5	10.8	0.0
10 to 29	12.2	8.7	1.6
30 to 49	6.1	5.4	4.8
50 to 69	11.3	15.1	6.4
70 to 89	12.6	12.9	8.0
90 to 99	10.8	12.9	9.6
100	27.7	34.3	69.8
N	231	93	63

Table 4-25. (Continued)

Number of Crew	All Tri-County Fishermen [2] Percent	Tri-County Fishermen that Fish in CINMS Percent	Tri-County Fishermen NOAA Samples [3] Percent
0	20.8	12.2	13.1
1	43.3	42.2	55.7
2	27.3	35.6	16.4
3 to 4	7.8	8.9	13.2
5 to 6	0.8	1.1	0
Greater than 6	0	0	1.6
N	231	90	61
Mean	N/A	1.48	1.52
BOAT OWNERSHIP	Percent	Percent	Percent
Owner	95.7	95.7	84.3
Non Owner	4.3	4.3	15.7
N	237	93	57
RESIDENCE/HOME PORT			
County of Residence	Percent	Percent	Percent
Ventura	27.7	47.3	39.1
Santa Barbara	32.8	44.8	54.7
San Luis Obispo	39.5	8.8	6.3
N	238	91	64
Home Port	Percent	Percent	Percent
Port Hueneme	2.5	2.2	7.8
Channel Islands/Oxnard	16.9	29.3	15.6
Ventura Harbor	9.1	16.3	14.1
Santa Barbara	30.9	48.9	57.8
Port San Luis/Avila Beach	15.6	1.1	0
Morro Bay	23	2.2	0
Other	2	0	4.7
N	243	92	64

1. Tri-County area is San Luis Obispo, Santa Barbara and Ventura Counties.
2. All Tri-County Fishermen and Tri-County Fishermen that Fish in CINMS are from a study funded by the U.S. Dept. of Interior, Minerals Management Service to Utah State University researchers Ron Little and Joanna Endter-Wada.
3. NOAA Samples are the ones derived from contracts with Dr. Craig Barilotti and Dr. Caroline Pomeroy.

Baseline Relationships with Consumers

Consumer's Surplus is analyzed in Chapter 5, and baseline data are presented here. Table 4-26 summarizes project area landings, U.S. landings, and U.S. supply and the proportions of project area supply relative to that of the U.S. for eight of the species/species groups. The information is from the National Marine Fisheries Service for 1999. It appears that squid and urchins are the only species/species groups for which significant proportions of U.S. landings come from the project area. The United Nations, Food and Agricultural Organization (FAO) reports a 1999 world commercial catch of squid of 3,373,463 metric tons or 7,438,486 million pounds. Project area landings were 2.15 percent of world supply and 1999 was a record year for squid in the project area. FAO also reports the 1999 world commercial catch of urchins of 118,750 metric tons or 261,844 million pounds. Project area landings were 2.24 percent of world supply.

Table 4-26. Relative Supply of Selected Sanctuary Commercial Species, 1999

	Landings		Landings		Landings		Supply	
	CINMS	CINMS	U.S.	U.S.	CINMS/U.S.	CINMS/U.S.	U.S.	CINMS/U.S.
	1999	1999	1999	1999	1999	1999	1999	1999
Species/Species Group	(Millions lbs)	(Millions $)	(Millions lbs)	(Millions $)	% of lbs	% of $	(Millions lbs)	% of lbs
Squid	159.564	26.545	258.198	71.172	61.80	37.30	N/A	N/A
Urchins	5.855	5.969	33.55	35.647	17.45	16.74	N/A	N/A
Spiny Lobster	0.121	0.951	6.692	29.754	1.81	3.20	90.586	0.13
Prawn & Shrimp	0.178	0.726	304.173	560.501	0.06	0.13	1,083.60	0.01
Crab	0.247	0.313	458.307	521.237	0.05	0.06	N/A	N/A
Rockfishes	0.192	0.553	60.223	30.436	0.32	1.82	N/A	N/A
Flatfishes	0.121	0.324	411.548	214.642	0.03	0.15	N/A	N/A
Tuna	0.168	0.054	58.12	86.254	0.29	0.06	N/A	N/A

Sources: Current Fishery Statistics No. 2000, Fisheries of the United States, 2000. National Marine Fisheries Service and California Department of Fish and Game, Marine Fisheries Statistical Unit.

Fisheries Access

For economic analysis, it is critical to understand the structure of who can enter the fishery, if there are constraints on the amount and timing of total take allowed and what is the current capacity to catch the fish stock. While most fisheries in the project area require permits, they fit into the most permissible types of permit structure. These permit types are listed below:

- A permit system where there are no restrictions on the number of permits, only requirements to possess one. The fishery may have some total allowable take, but not specified by fishermen (first come first serve). In this type the economic analysis of open access fisheries applies.

- A permit system where the number of permits is limited, and criteria for obtaining a permit are set. The capacity of the fleet, however, is such that they could catch an amount above the total allowable catch. One might describe this as limited entry, but it has no real effect economically or biologically because of the capacity of the fleet. This would still be analyzed as an open access fishery.

- A permit system where the number of permits is limited, criteria for obtaining a permit are set, and the capacity of the fleet is controlled to where it cannot exceed total allowable catch. In this case there are no Individual Transferable Quotas, but there is the possibility of the participants in the fishery earning economic rents. This is likely to be a derby fishery, where participants compete for a larger share of the catch. Because of the limits on capacity, this is not analyzed as an open access fishery.

- A permit system where fishermen possess Individual transferable Quotas (ITQs). A limited number of fishermen are given ITQs, which specify a certain share of the total allowable catch. This avoids the derby fishery problem and since one can buy and sell the ITQs, it solves the capacity problem and fosters economic efficiency. This is not an open access fishery.

Using the above criteria, all of the commercial fisheries in the project area can currently be characterized as open access fisheries. The squid/wetfish fishery is currently considering implementing a limited entry program in the current draft management plan. The nearshore finfish fishery has reduced its capacity, and is considering limited entry. There are no present analysis of whether these limits would lead to economic rents in the fishery. Therefore, no analyses of the effects of MPAs on economic rents are possible.

4.4.3 Recreation and Tourism

Recreational activities occur primarily in nearshore areas particularly along the mainland and around the Channel Islands. Examples of common offshore recreational activities include sportfishing, sailing, boating, and swimming. In addition, the coastal and offshore marine environments are ideal locations for tourist activities. Tourist-related activities include sightseeing, whale watching, sportfishing, pleasure boating, and diving.

4.4.3.1 Consumptive Activities

Recreational / Sport fishing and consumptive diving

Recreational (sport) fishing involves hook-and-line fishing from piers and docks, jetties and breakwaters, beaches and banks, private or rental boats, and commercial passenger fishing vessels. Recreational fishing also includes activities such as spear and net fishing. Recreational fisheries in the project area access both nearshore and offshore areas, targeting both bottom fish and mid-water fish species. Consumptive recreational divers use both private and rental boats and commercial passenger fishing vessels. They also SCUBA and free dive from the shore in a variety of locations.

The project area is a leading recreational fishing area along the West Coast. Weather and sea conditions allow for year-round fishing. The coastlines around the Channel Islands are popular sportfishing areas; although the majority of kelp beds are within one nm of shore, some fishing areas extend far from shore and include lingcod and rockfish grounds west of San Miguel Island, broadbill swordfish, marlin, and mako shark waters south of Santa Cruz Island, and kelp beds offshore and surrounding portions of all the islands.

The sportfishing industry in California is composed of commercial passenger fishing vessels (CPFV), private boats, and shore anglers. The CPFV's take groups of anglers out on 1/2–day, 3/4–day, full day, and multiday trips. The majority of 1/2– and 3/4–day trips fish within or near the kelp beds except in the summer when California barracuda (*Sphyraena argentea*) and Pacific bonito (*Sarda chiliensis*) are present (Crooke pers. comm.). CPFV dive trips are often multi-day trips going to one or more of the offshore islands. These trips focus on certain species during various seasons, such as lobster during the open season.

A large number of sport divers (both free divers and SCUBA divers) spearfish for many of the species caught by hook and line. Species commonly targeted by consumptive divers include many rockfish species and kelp bass, halibut, yellowtail and white seabass, as well as lobster and scallops. Divers are generally limited to the shallowest waters of the project area between the shallow intertidal to depths around 130 feet.

Commercial passenger fishing vessels (CPFVs) frequently offer one-day sportfishing excursions from either Ventura or Santa Barbara harbors. Types of fish landed on commercial passenger fishing vessels include kelp bass, mackerel, California sheephead, halfmoon, and whitefish. Offshore fishing focuses on more mobile species like yellowtail, tuna, white seabass, and barracuda.

The largest numbers of fish caught for recreational purposes are caught within 3 miles of shore. Barred surfperch, California halibut, jacksmelt, pacific mackerel, kelp bass, rockfish genus, white croaker are a few of the species that represent the largest numbers that were caught.

4.4.3.2 Non-consumptive Activities

Whale watching

Whale watching in the Channel Islands is popular, due to the high frequency of sightings and diversity of marine mammals to be seen. Day trips are offered from several areas landings including Santa Barbara, Ventura and Channel Islands harbors.

Non-consumptive Diving

The project area is considered to have some the most highly sought after nonconsumptive diving in California. Interest in nonconsumptive diving in the project area is keen, due to the beautiful marine habitat, shipwrecks, and other underwater historical sites. Morris and Lima (1996) describe the history of submerged cultural resources (e.g., shipwrecks) of the Channel Islands, and systematically review the archeological sites from field work in this marine area. Over 100 vessels have wrecked in the Channel Islands National Park and National Marine Sanctuary; 21 of these have been located. A literature survey of knowledge of the marine areas shipwrecks is also found in Howorth and Hudson (1985). Nonconsumptive divers enjoy interacting with the marine environment, exploring new habitats, and photography.

Sailing

Sailing is a popular pastime in the project area. The Channel Islands are within reach of several ports for single or multiple day trips. Users who sail in the project area likely also participate in other consumptive and/or nonconsumptive recreational activities during their trips.

Kayaking/island sight-seeing

Several operations offer sea kayaking excursions in the project area. Users can also take kayaks out to the islands on commercial or private vessels, and spend single or multiple days kayaking along the shoreline of the Channel Islands. Due to abundant marine life and the presence of large sea caves and rock formations, the Channel Islands are considered a primary destination of interest for sea kayakers in California.

Economic Overview of Recreational Activities

This section provides the baseline economic measures for the recreation industry. Consumptive recreation includes recreational fishing from a charter/party boat, fishing from a private household/rental boat, consumptive diving from a charter/party boat and consumptive diving from a private household/rental boat. Non-consumptive recreation includes non-consumptive diving, whale watching, sailing and kayaking/sightseeing from for hire or charter/party boats. No information was found on non-consumptive activities from private household/rental boats, so non-consumptive uses are undercounted. 1999 is the baseline year used for extrapolating future impacts.

A previous assessment of recreational fishing (Leeworthy and Wiley 2000) has summarized information available for years 1993 to 1998 from the National Marine Fisheries Service, Marine Fishing Statistics Survey (MRFSS). MRFSS data showed a downward trend in fishing trips and catch for Southern California over this period. Total trips had declined 26.4 percent (Table 4-27). For the top 20 species, in terms of total number of fish caught, 10 had downward trends, 7 had no trend and 3 had upward trends. These trends were contrasted with the trends between 1991 and 1996, for all of California, based on the U.S. Fish and Wildlife Survey of Fishing, Hunting and Wildlife Associated Recreation (USFWS 1991 and 1996). This latter survey showed a slight decrease in the number of recreational anglers (-0.76 percent), but an increase in the number of angler days (27.88 percent). Although the definitions of the populations covered are different between the surveys, the differences in trends could not be reconciled because the MRFSS Northern California data also showed a downward trend.

Table 4-27. Number of Marine Recreational Fishing Trips in Southern California: 1993 - 2000 (thousands)

Year	Total	Private/ Rental Boat	Charter/ Party Boat	Shore
1993	4,037	1,625	1,174	1,238
1994	4,749	1,932	1,201	1,616
1995	4,301	1,701	1,129	1,471
1996	3,768	1,478	889	1,401
1997	3,232	1,275	788	1,169
1998	2,973	1,325	674	974
1999	2,437	1,019	617	801
2000	3,782	1,755	956	1,071
Percent Change 1993 - 1999				
	-39.6	-37.3	-47.4	-35.3
Percent Change 1993 - 2000				
	-6.3	8.0	-18.6	-13.5

Source: National Marine Fisheries Service, Marine Recreational Fisheries Statistics Survey (MRFSS) (http://www.st.nmfs.gov/st1)

Species like California halibut, white seabass, Pacific barracuda and yellowtail, which were not among the top 20 species between 1993 and 1998, were in the top 20 or close in 1999 and 2000 (Yellowtail actually ranked 21). In 2000, the number of trips ended the downward trend in total trips and across all boat modes and total catch increased as well. The number of trips increased dramatically between 1999 and 2000 (55.19 percent). The number of trips rebounded to almost their 1996 level. Overall, the trend in trips is still down from the 1993 level (-6.3 percent).

Many of the top 20 species had downward trends in the number of fish caught (Table 4-28). The top 20 species also changed fairly dramatically (Table 4-29). In 1999 and 2000, all the rockfish species previously among the top 20 between 1993 and 1998 dropped out of the top 20, except vermillion rockfish and bocaccio. Vermillion rockfish were ranked 13th in 1999 and 17th in 2000 and bocaccio was ranked number 19 in 1999 and 21 in 2000. Species ranked number 11 to 20 in 1993 were all out of the top 20 in 2000, even though only three of these species showed downward trends in catch between 1993 and 1998.

Table 4-28. Summary of Trends in Marine Recreational Catch in Southern California: 1993 - 1998

Ranking 1993	Ranking 1998	Species	Number	Mean Length
1	1	Chub Mackerel	down	no trend
2	2	Kelp Bass	down	no trend
3	3	Barred Sand Bass	down	no trend
4	5	White Croaker	down	no trend
5	6	Pacific Bonito	down	up
6	4	Barred Surf Perch	up	up
7	7	Vermillion Rockfish	down	no trend
8	13	Bocaccio	down	no trend
9	8	Pacific Sanddab	no trend	no trend
10	9	California Sheepshead	no trend	no trend
11	18	Chilipepper Rockfish	down	no trend
12	11	Copper Rockfish	no trend	no trend
13	10	Yellowfin Tuna	no trend	down
14	15	Lingcod	no trend	up
15	14	Dolphin	no trend	up
16	17	Brown Rockfish	down	no trend
17	16	Gopher Rockfish	up	no trend
18	12	Blue Rockfish	no trend	no trend
19	20	Canary Rockfish	down	up
20	19	Yellowtail Rockfish	up	up

Source: National Marine Fisheries Service, Marine Recreational Fisheries Statistics Survey (MRFSS) (http://www.st.nmfs.gov/st1)

Table 4-29. Changes in Top 20 Species in Marine Recreational Catch in Southern California, 2000

Ranking 1999	Ranking 2000	Species
2	1	Barred Sand Bass
4	2	Kelp Bass
1	3	Chub Mackerel
5	4	**California Halibut**[1]
3	5	**Pacific Barracuda**
6	6	White Croaker
12	7	**Spotted Sand Bass**
15	8	Pacific Sanddab
7	9	**California Scorpionfish**
10	10	**Ocean Whitefish**
8	11	California Lizardfish
21	12	**Yellowtail**
17	13	**White Sea Bass**
16	14	**Jacksmelt**
14	15	**Queenfish**
-	16	Pacific Bonito
13	17	Vermillion Rockfish
-	18	Yellowfin Tuna
-	19	**Shovelnose Guitarfish**
18	20	California Sheepshead

1. Species in bold were not among the top 20 1993 through 1998.
Source: National Marine Fisheries Service, Marine Recreational Fisheries Statistics Survey (MRFSS) (http://www.st.nmfs.gov/st1)

Person days of activity

In 1999, there were an estimated 437,908 total person-days (one personal undertaking an activity for any part of a day or a whole day) of consumptive recreation in the project area (Table 4-30). Fishing from a private household boat was the top activity with over 214 thousand person-days (49 percent of the consumptive recreation activity) followed by about 159 thousand person-days of fishing from charter/party boats (36 percent of the consumptive recreation activity). Consumptive diving accounted for the remaining 15 percent of consumptive recreation activity. In 1999, 21 percent of the private household boat fishing and about 26 percent of the charter/party boat fishing in Southern California was done in the project area. Spatial distributions of charter/party boat fishing, charter/party boat consumptive diving, private boat fishing, and private boat consumptive diving are shown in Figures 4-14, 4-15, 4-16, and 4-17 respectively.

Table 4-30. Person-days of Recreational Activity in the Sanctuary, 1999

	Person-days (number)	Person-days (percent)
Consumptive Activities		
Charter/Party Boat Fishing	158,768	36%
Charter/Party Boat Consumptive Diving	17,935	4%
Private Boat Fishing	214,015	49%
Private Boat Consumptive Diving	47,190	11%
Total Consumptive	**437,908**	**100%**
Non-consumptive Activities		
Whale Watching	25,984	62%
Non-consumptive Diving	10,776	26%
Sailing	4,015	10%
Kayaking/Island Sightseeing	1,233	3%
Total Non-consumptive	**42,008**	**100%**

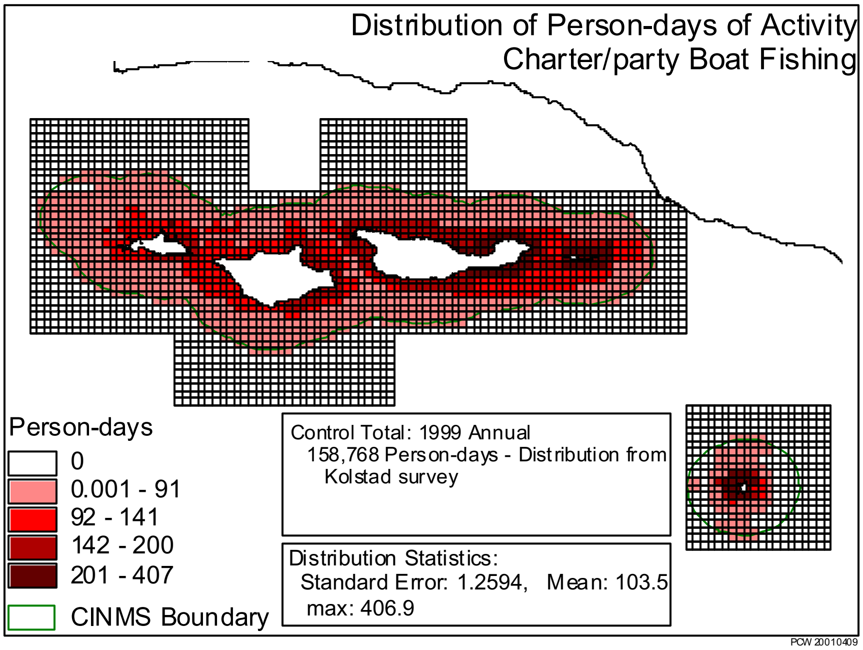

Figure 4-14. Spatial distribution of person-days of charter/party boat fishing in the project area.

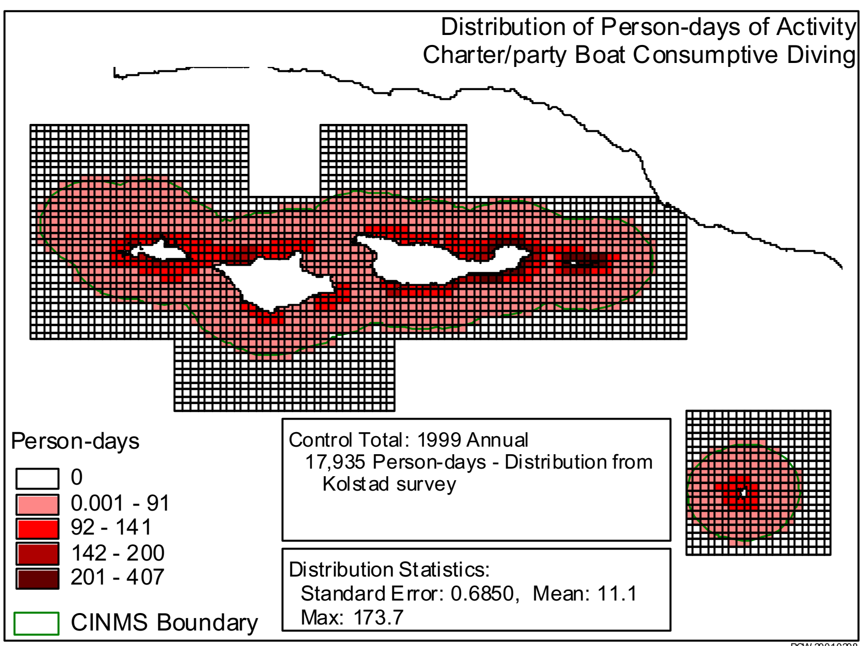

Figure 4-15. Spatial distribution of person-days of charter/party boat consumptive diving in the project area.

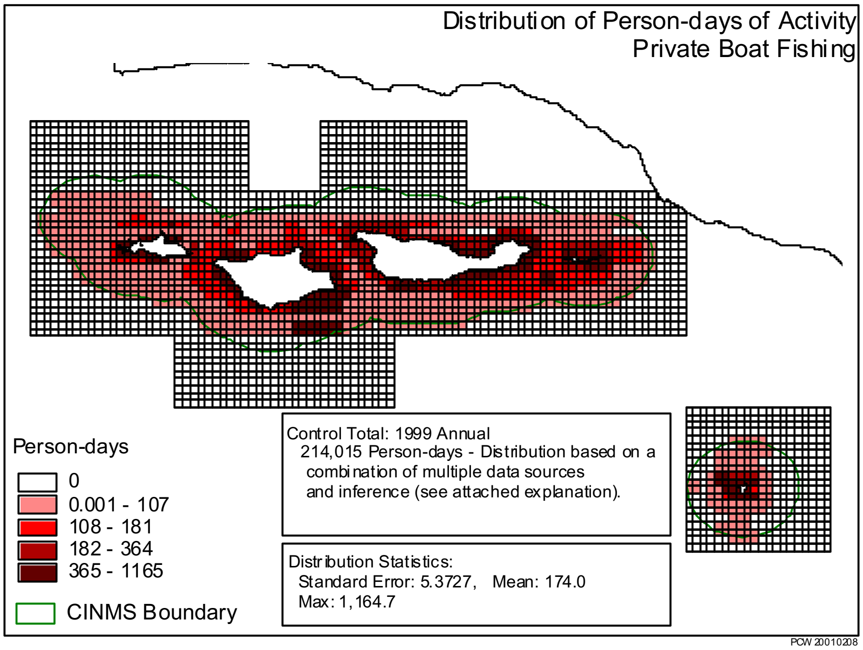

Figure 4-16. Spatial distribution of person-days of private boat fishing in the project area.

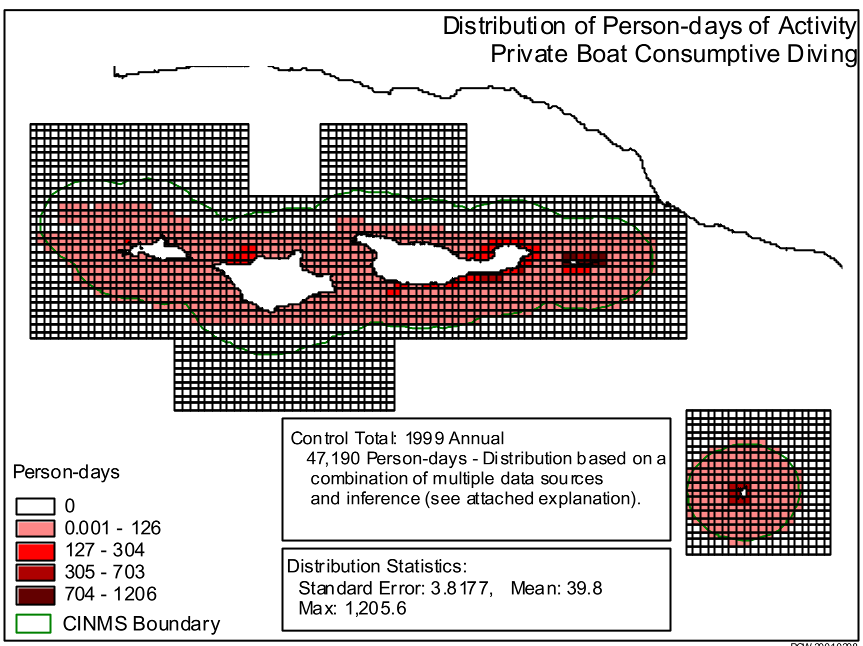

Figure 4-17. Spatial distribution of person-days of private boat consumptive diving in the project area.

In 1999, there were an estimated 42,008 person-days of non-consumptive recreation from “for hire” operations in the project area. As mentioned above, an estimate the amount of non-consumptive recreation activity from private household boats was not possible. Whale watching was the top non-consumptive recreational activity with about 26 thousand person-days (62 percent of all non-consumptive recreation activity) followed by non-consumptive diving with almost 11 thousand person-days (26 percent of all non-consumptive recreation activity). Sailing and kayaking/island sightseeing accounted for the remaining 13 percent of non-consumptive recreation activity. Spatial distributions of whale watching, non-consumptive diving, sailing, and kayaking/island sightseeing are shown in Figures 4-18, 4-19, 4-20, and 4-21, respectively.

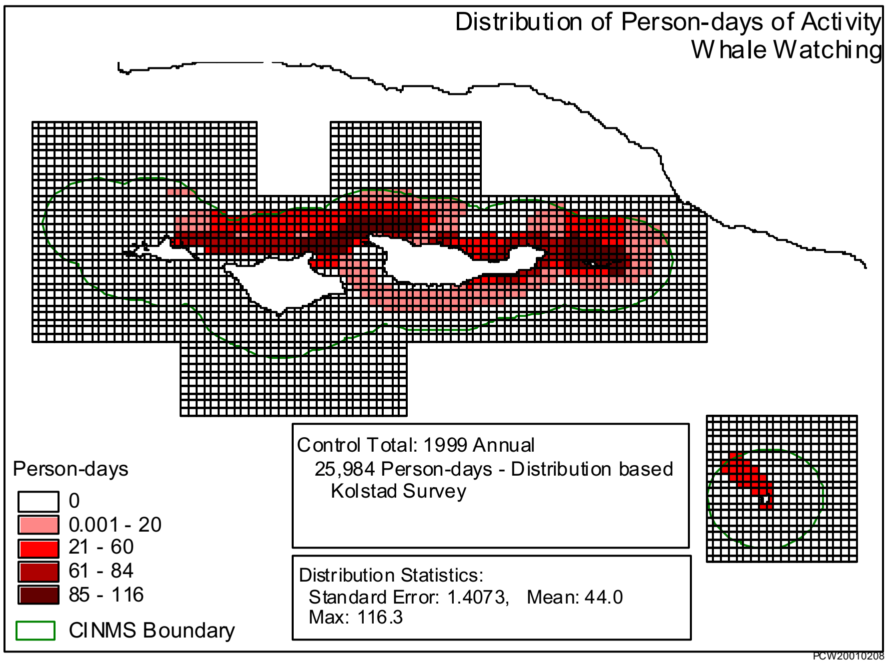

Figure 4-18. Spatial distribution of person-days of whale watching activity in the project area.

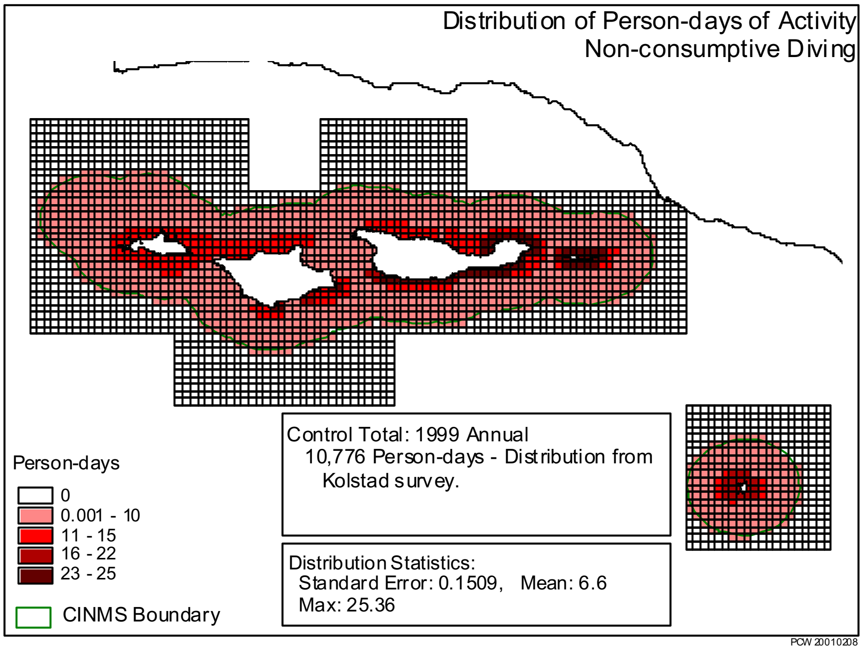

Figure 4-19. Spatial distribution of person-days of non-consumptive diving activity in the project area.

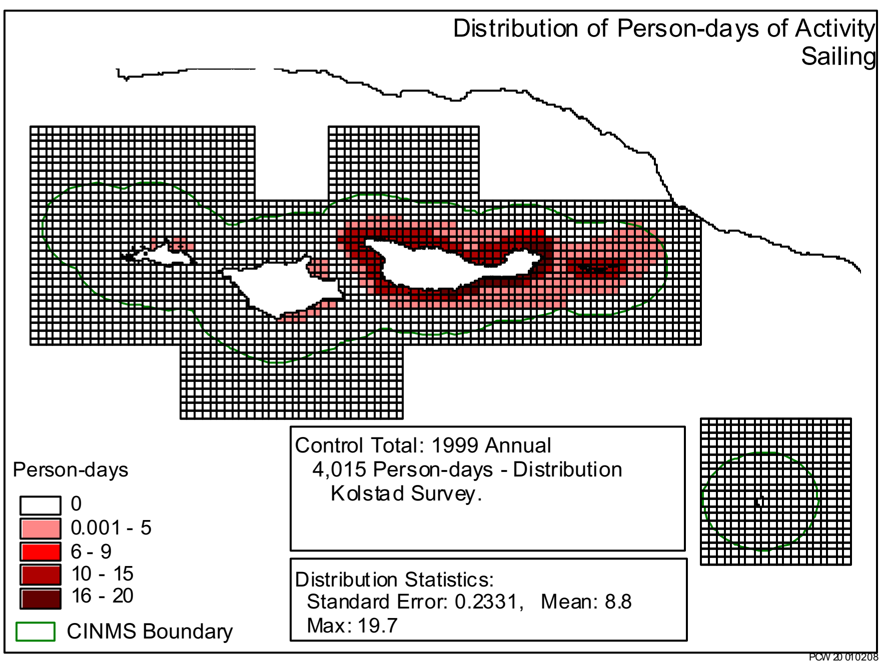

Figure 4-20. Spatial distribution of person-days of sailing activity in the project area.

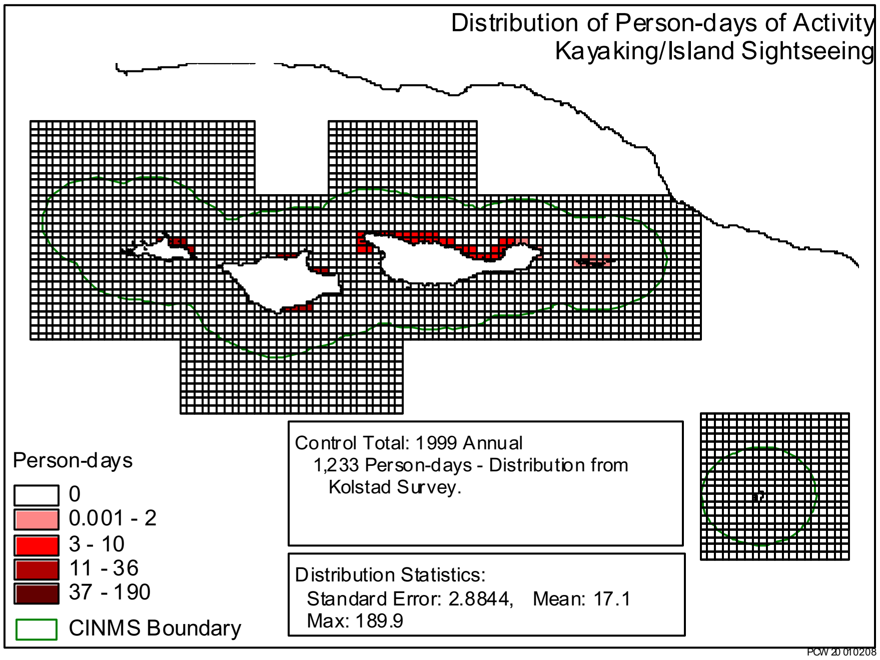

Figure 4-21. Spatial distribution of person-days of kayaking/sight-seeing activity in the project area.

In 1999, the recreation industry included a total of 479,916 person-days of consumptive and non-consumptive recreation. Consumptive recreation was 91.25 percent of all recreation activity in the project area. The "for hire" industry (51 charter/party boat/guide operations) accounted for almost 46 percent of all the person-days of recreation activity. This is important because the estimates of use from this industry were based on a census, not a sample, of all operators who operate in the project area (Leeworthy and Wiley 2002). Table 4-31 shows the total number of operators, person-days, revenues, costs and profits for this industry from activities in the project area. It is important to note that adding up the number of operators across activities would add to more than 51 because some operators provide services for multiple activities.

Table 4-31. Charter/Party Operations in the Sanctuary, 1999

	Number of Operators[1]	Total Person-days	Total Revenue	Total Cost	Total Profit
Consumptive Activities					
Charter/Party Boat Fishing	18	158,768	$ 7,692,525	$ 7,316,229	$ 376,296
Charter/Party Boat Consumptive Diving	10	17,935	$ 1,089,839	$ 1,045,835	$ 44,004
Total Consumptive	**25**	**176,703**	**$ 8,782,364**	**$ 8,362,064**	**$ 420,300**
Non-consumptive Activities					
Whale Watching	8	25,984	$ 1,508,049	$ 1,498,828	$ 9,221
Non-consumptive Diving	7	10,776	$ 687,585	$ 641,272	$ 46,313
Sailing	8	4,015	$ 264,700	$ 246,618	$ 18,082
Kayaking/Island Sightseeing	4	1,233	$ 125,558	$ 116,337	$ 9,221
Total Non-consumptive	**26**	**42,008**	**$ 2,585,892**	**$ 2,503,055**	**$ 82,837**

1. The totals do not equal the sums of the individual activities because operators have customers who participate in more than one activity.

Expenditure Profiles

Table 4-32 shows the expenditure profiles developed for each activity/boat mode. Low food, beverage and lodging costs would indicate a low percentage of users being overnight visitors or dominated by local users. In 1999, coastal residents accounted for 86.7 percent of charter/party boat trips and 96.86 percent of private household boat trips for fishing in southern California (NMFS, MRFSS). Not all the profiles found had consistent categories; sometimes food and beverage was reported separately and sometimes they were aggregated together. When reported separately, the separated categories were used in the impact analysis. The profiles for charter/party boat fishing and private household/rental boat fishing are from a 2000 study of Southern California marine recreational fishing (Gentner, Price and Steinback 2001). See Leeworthy and Wiley (2002) for a discussion and critique of the approach used in an American Sportfishing Association report.

Table 4-32. Expenditure Profiles for Recreation Activities in the Sanctuary, 1999

	Expenditures Per Person-day (1999 $)			
Expenditure	Fishing Charter/Party Boat	Fishing Private Boat	Diving Charter/Party Boat	Diving Private Boat
Boat Fees[1]	$47.62 - 60.74	n/a	$40.21 - 92.56	n/a
Boat Fuel	n/a	$ 12.74	n/a	$ 19.00
Food, Bev, Lodging	n/a	n/a	$82.00	$ 11.00
Food	$ 15.47	$ 7.60	n/a	n/a
Lodging	$ 8.65	$ 1.20	n/a	n/a
Transportation	n/a	n/a	$10.00	$ 9.00
Private Transportation	$ 16.64	$ 8.90	n/a	n/a
Public Transportation	$ 33.07	$ 1.89	n/a	n/a
Equipment/Equip. Rental	$ 6.01	$ 0.91	n/a	$ 5.00
Miscellaneous	n/a	n/a	$15.00	$ 10.50
Access/Boat Launch Fees	$ 1.18	$ 1.52	n/a	n/a
Air Refills	n/a	n/a	n/a	$ 7.00
Bait/Ice	$ 0.52	$ 6.77	n/a	$ 2.50
Total[2]	$129.16-$142.28	$ 41.53	$132.21-$184.56	$64.00
Expenditure	Whale Watching Charter/Party Boat	Non-consumptive Diving	Sailing Charter/Party Boat	Kayaking/Island Sightseeing
Lodging	$ 53.00	$ 53.00	$ 53.00	$ 53.00
Eating & Drinking	$ 29.00	$ 29.00	$ 29.00	$ 29.00
Transportation	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Charter Boat Fee[1]	$53.43-60.19	$40.56-81.78	$61.99-177.61	$50.77-104.67
Miscellaneous	$ 15.00	$ 15.00	$ 15.00	$ 15.00
Total[2]	$160.43-167.19	$147.56-188.78	$168.99-284.61	$157.77-211.67

1. Boat fees used were actual by county and activity from the Kolstad survey. They are:

	SB	Ventura	LA
Charter/Party Boat Fishing	$ 60.74	$ 47.62	$ 59.95
Charter/Party Boat Diving	$ 40.21	$ 64.50	$ 92.56
Whale Watching	$ 53.43	$ 60.19	n/a
Non-Consumptive Diving	$ 40.56	$ 81.78	$ 48.48
Sailing	n/a	$ 61.99	$ 177.61
Kayaking/Island Sightseeing	$ 104.67	$ 50.77	n/a

2. The total varies because we used the actual charter/party boat fee by activity

Baseline Economic Impacts of Recreation in CINMS

The baseline impacts of consumptive and non-consumptive recreational activities are summarized in Tables 4-33 and 4-34.

Table 4-33. Baseline Consumptive Recreational Activity

	Charter/Party Boat Fishing	Charter/Party Boat Diving	Private Boat Fishing	Private Boat Diving
Person-days	158,768	17,934	214,015	47,190
Market Impact				
Direct Sales	$ 20,638,407	$ 3,008,782	$ 8,888,043	$ 2,595,450
Direct Wages and Salaries	$ 9,475,042	$ 1,449,065	$ 2,499,255	$ 683,447
Direct Employment	279	48	85	24
Total Income				
Upper Bound	$ 16,581,324	$ 2,535,864	$ 4,373,697	$ 1,196,032
Lower Bound	$ 14,212,564	$ 2,173,598	$ 3,748,883	$ 1,025,171
Total Employment				
Upper Bound	418	72	127	37
Lower Bound	348	60	106	31
Non-Market Impact				
Consumer's Surplus [1]	$ 1,838,358	$ 207,642	$ 2,478,026	$ 545,243
Profit [2]	$ 376,295	$ 44,004	n/a	n/a

1. Consumer's Surplus is calculated by multiplying the average consumer's surplus per person per day from the the studies on the attached reference list (11.58) by the number of person days in this table.
2. Profit is used as a proxy for producer's surplus.

Table 4-34. Baseline Non-consumptive Recreational Activity

	Whale Watching	NC Diving	Sailing	Kayaking/ Sightseeing
Person-days	25,984	10,776	4,015	1,233
Market Impact				
Direct Sales	$ 4,288,337	$ 1,858,879	$ 694,305	$ 257,489
Direct Wages and Salaries	$ 2,084,969	$ 899,833	$ 326,370	$ 129,259
Direct Employment	72	31	10	5
Total Income				
Upper Bound	$ 3,648,695	$ 1,574,708	$ 571,147	$ 226,203
Lower Bound	$ 3,127,453	$ 1,349,750	$ 489,554	$ 193,888
Total Employment				
Upper Bound	108	47	16	8
Lower Bound	90	39	13	7
Non-Market Impact				
Consumer's Surplus [1]	$ 300,862	$ 124,767	$ 46,489	$ 14,277
Profit [2]	$ 157,235	$ 46,313	$ 18,020	$ 2,767

1. Consumer's Surplus is calculated by multiplying the average consumer's surplus per person per day from the the stuc on the attached reference list (11.58) by the number of person days in this table.
2. Profit is used as a proxy for producer's surplus.

4.4.4 Oil and Gas

Under Federal regulations, no new offshore oil or gas activity is allowed within the project area. Oil and gas development does occur in the Santa Barbara Channel. Current onshore facilities prepare crude oil for shipment to refining centers, and produce natural gas. A characterization of onshore facilities for offshore oil and gas activities is found in California Offshore Oil and Gas Energy Resources Baseline Conditions & Future Development Scenarios (MMS 1999).

Offshore oil and gas development has occurred in leased tracts in California waters (State waters) from the mean high tide line to 3 miles offshore, and Federal waters (from 3 to 200 miles offshore). There is currently one artificial island (Rincon Island) and one offshore oil drilling and production platform (Platform Holly in the Southern Ellwood Field) in State waters. See Section 4.2.3 (Water Quality) for information on natural oil seeps near the project area **and pages 4-6 through 4-8 for a detailed discussion of potential environmental impacts related to oil platforms.**

Several new and proposed projects could have impacts in the area. Of particular concern is the fact that these proposals would significantly lengthen the lifespan of existing oil facilities that would otherwise be decommissioned. One proposal would convert Platform Grace to a Liquified Natural Gas (LNG) facility. This proposal could increase not only the life span of the facility but also lead to increased vessel traffic. Arguello, Inc. resubmitted an application for development of the Rocky Point Unit on August 14, 2002. Arguello Inc. proposes to develop a federal Outer Continental Shelf (OCS) lease in the Rocky Point Unit by drilling up to 8 extended-reach wells from the three existing OCS platforms in the Point Arguello Unit. Drilling of the Rocky Point Unit wells would last approximately 2-3 years with production lasting approximately 8-10 years. Oil and gas processing would occur offshore at the existing platforms with the existing equipment. The produced oil would be dehydrated and stabilized and transported in existing pipelines to the Gaviota Facility, where it would be heated and shipped by pipeline to refineries. Finally, Nuevo Energy Company and Mission Resource Corporation are requesting a revision to the Santa Barbara County Point Pedernales Project Final Development Plan (FDP) to allow development (drilling and production operations) of a proposed California State Lease (Tranquillon Ridge Oil Field). The proposed Tranquillon Ridge Project would include directionally drilling up to 30 wells from Platform Irene into the State Tidelands, using extended-reach technology. The proposed project would have a life of 30 years. An Environmental Impact Report (EIR) was released for the Project on February 7, 2002 and the comment period closed on March 25, 2002. Key issues assessed in the EIR include the impacts of constructing and operating new facilities along the existing Pt. Pedernales pipelines, the extension of life of the Pt. Pedernales facilities over what was assumed when the project was originally approved, and the increased throughput of oil over current levels. At a Planning Commission hearing on June 20, 2002 the Tranquillon Ridge Project did not receive approval on a 2-2 vote. Nuevo appealed the Planning Commission's action to the Board of Supervisors who heard testimony regarding this project on September 10, 2002. The appeal hearing was continued to September 24.

4.4.5 Vessel Traffic and Harbors

4.4.5.1 Commercial Vessel Traffic

The Los Angeles-Long Beach Harbor is the busiest on the west coast (McGinnis, 1990). Commercial vessels use the shipping lanes of the Santa Barbara Channel. To help direct offshore vessel traffic in the Santa Barbara Channel, a Traffic Separation Scheme (TSS) was designated in the project area to separate opposing flows of vessel traffic into lanes, including a zone between lanes where traffic is to be avoided. Vessels are not required to use any designated TSS, but failure to use one would be a major factor for determining liability in the event of a collision.

The most recent survey of the number of commercial vessels that use the shipping lanes of the channel is found in the County of Santa Barbara Energy Division (1989) and the National Maritime Research Center (1981). The County of Santa Barbara (1989) study reported 8,458 vessels, or 23.3 trips per day, during 1987 and projected an estimated 15,864 per year, or 43.2 trips per day, during 2000.

4.4.5.2 Ports and Harbors

Santa Barbara Harbor, built in 1926, is a 1,068-slip harbor and is used primarily by fishing, commercial, and recreational vessels. It is a popular destination for recreational boaters, fishermen, and tourists. The harbor offers a number of boating services including maintenance, hull cleaning, repairs, and towing.

Ventura Harbor, built in 1963, is located approximately 65 miles northwest of Los Angeles. The harbor has increased in size so that it now encompasses 152 acres of land, 122 acres of water, and has 1,375 slips. This small harbor is used primarily by recreational and commercial vessels, and provides several services and outdoor activities. Its proximity to the Channel Islands makes it an excellent point of origin for day or extended trips. Although it is used primarily by recreational and commercial fishing vessels, Ventura Harbor does offer berths for some supply and work vessels that service offshore platforms (MMS 1999).

Channel Islands Harbor is located in Oxnard, halfway between Ventura Harbor and Port Hueneme. With nine marinas and four yacht clubs, the harbor is home to more than 2,800 recreational and commercial vessels. Channel Islands Harbor is the closest harbor to the Channel Islands, making it a convenient location for day or extended trips. Public facilities and services include laundry rooms, restrooms and showers, picnic areas, marine supplies, and maintenance and repair shops. Vessels associated with the offshore oil and gas industry typically do not use Channel Islands Harbor (MMS 1999).

Port Hueneme is the only deep water port between Los Angeles and San Francisco, and is used by commercial ships to load and unload goods. Port Hueneme is also used by supply and crew vessels that service offshore platforms (MMS 1999).

4.4.6 Noise

Ambient noise levels can vary dramatically, depending upon proximity to major metropolitan areas, shipping traffic lanes, commercial fishing operations, and offshore oil and gas activities, as well as ambient oceanographic conditions and seafloor composition and topography. In busy port regions, shipping activities can contribute to ambient nosie levels, although such sources are transitory. In addition, commercial vessels and tankers moving up and down the west coast also contribute nosie to the marine environment. Shipping traffic is most significant at frequencies from 20 to 300 Hertz (Hz). Fishing vessels produce high frequency sound peaking at 300 Hz, whereas larger cargo vessels produce lower frequency sounds (MMS 2001). Marine mammals also produce underwater sounds which can travel up to 185 km for fin whale vocalizations (MMS 2001). Humpback whales produce sounds between 20 to 2,000 Hz and gray whales sounds are from less than 100 Hz to 2 kHz.

A growing number of studies are documenting impacts to living resources including behavioral changes and physical effects due to exposure to anthropogenic noise and pressure waves in the marine environment. In the project area, vessel traffic is the primary source of acoustic disturbance. An estimated 7,600 bulk carriers and container vessels travel through the Santa Barbara Channel every year. Other sources of anthropogenic noise include: air traffic, seismic exploration, military activity, recreational and commercial boats, acoustic thermometry and military low frequency testing. Low frequency noise has already been shown to have impacts on marine mammals. Gray whales exposed to 120 decibel sounds tend to deviate from their migration paths and sperm whales, faced with higher levels, can fall silent for hours or days.

The significance of these reactions, and the cumulative impacts, are still not known. It has been found that fish, particularly haddock, bonefish and cod, may be impacted by low frequency sound, and may experience possible permanent acoustic damage. Also of concern is the potential for “masking” as sounds may be used by fish to mate, feed and avoid predators, are lost to anthropogenic noise. The most profound impacts may be specific to hatchlings or fry. Noise impacts may destroy them, or retard their development.

Low frequency active sonar (LFA) is Navy technology using passive equipment to detect foreign vessels. The ocean is swept with low frequency sound, reportedly over 230 decibels near the source, casting a sonic array for hundreds of miles. In two separate studies captive marine mammals, hearing loss began at 140dB and 190dB. At close range, the small bones, or ossicles, that carry sound waves from the eardrum to the inner ear suffer damage, bringing on permanent damage or possibly rupturing the oval window that protects the inner ear, causing fatal loss of cerebrospinal fluid.

Response of animals to acoustic stimuli has generally shown alterations in behavior and physiological effects, depending on the species studied, characteristics of the stimuli (e.g., amplitude, frequency, pulsed or non-pulsed), season, ambient noise, previous exposure of the animal, physiological or reproductive state of the animal, and other factors. Possible adverse effects from loud sounds include discomfort, masking of other sounds, and behavioral responses resulting in avoidance of the noise source (MMS 1984). Whales have been documented altering their migration routes in response to noise. These behavior changes range from startle to avoidance responses. Sperm whales have been observed to dive immediately in response to a Twin Otter airplane passing 150 to 230 meters overhead (MMS 2001).

Very little data on the effects of sound on fish, larvae, and eggs have been collected. There are some data showing that sound can cause some damage to sensory cells of the ears of fishes, but not to the lateral line or cristae of the semicircular canals (vestibular receptor). Some behavioral studies of fish suggest that human-generated sounds affect a fish's ability to detect biologically meaningful environmental sounds. This is significant since croakers are known to produce sounds which may be used to communicate with one another. Strong sound waves (e.g. blasting, air guns for oil and gas exploration) have resulted in the death of fish due to bursting of their swim bladders.

Research has shown that many seabird species are disturbed by human activities, including boat noise, close to and within breeding colonies and at roosting sites (Carney and Sydeman 1999). Boating noise would include noise from motors, generators, radios, whistles, and gunshots. High-speed boating approaches are known to increase the level of disturbances (Carney and Sydeman 1999). Possible side effects from loud sounds include disruption of normal nesting and roosting activities, increased predation of eggs and chicks as result of flushing of birds from nests, and nest abandonment.

4.4.7 Cultural, Historic, and Archaeological Resources

A wealth of maritime cultural resources lies submerged in the waters of the project area and scattered along the shoreline of the Channel Islands.

Native American Cultural Resources

The Chumash Indian homeland lies along the coast of California, between Malibu and Paso Robles, as well as on the Northern Channel Islands. Before the Mission Period, the Chumash lived in 150 independent villages with a total population of about 18,000 people. In different parts of the region, people spoke different but related languages. The area was first settled about 13,000 years ago. Over time, the population increased and the people adapted their lifestyles to the local environment. Villages along the coastline, on the islands and in the interior had access to different resources, which they traded with one another.

This trade was made possible in part by the seagoing plank canoe, or tomol, which was invented about 2,000 years ago. The last Chumash tomols used for fishing were made about 1850. Today, there are still many people who can trace their ancestry back to these historic Chumash communities. Recently, interest in an active maritime program has resurfaced among the Chumash Indians. In 2001 a tomol was paddled from the coastline to the Channel Islands for the first time in over a century.

Many archeological artifacts have been found in the waters of the project area. It is also predicted by specialists that more important sites remain to be found, particularly those relating to submerged prehistorical living sites. These sites may include evidence of interactions with giant prehistoric mammals, which roamed the islands thousands of years ago.

Shipwrecks

Shipwrecks contain archaeological remains of our human past that preserve a point in history. Shipwrecks are valued by scholars, to learn about the past, and by maritime specialists, to learn about how currents, weather, technology and human error combine in ways that potentially damage the environment. Recreational divers value the shipwrecks for exploration.

The many known shipwrecks in the project area reflect the nationalities that have traversed the Santa Barbara Channel. Chinese junks, Russian and Mexican sailing ships, American coastal traders and Gold Rush-era steamships have all sunk in these waters. An inventory of over 140 shipwrecks dating from 1853 to 1980 has been documented in the project area. To date, about 20 sites have been located (Table 4-35).

Table 4-35. Shipwrecks with identified locations in the project area.

Vessel Name	Casualty Location	Year Built	Year Lost	Month	Cargo	Cause	Latitude	Longitude
*Aristocratis**	Santa Rosa Island, SW side (near Johnson's Lee)	1943	1949	12	Coal	Navigation	330° 54 N	1200° 06 W
Blue Fin J 245	Santa Rosa Island, Becher's Bay?	1930	1944	09		Unknown	330° 56 N	1190° 57 W
Chickasaw	Santa Rosa Island, near South Point	1942	1962	02	Toys	Navigation	330° 53 N	1200° 07 W
Comet	San Miguel Island, Wilson Rock, Simonton Cove	1886	1911	08	Lumber, 5000 board feet	Navigation, faulty chronometer	340° 03 N	1200° 23 W
Crown of England	Santa Rosa Island, Ford Point	1891	1894	11	Ballast	Navigation	330° 54 N	1200° 02 W
Cuba	San Miguel Island, Point Bennett	1897	1923	09	Coffee, Silver	Navigation	340° 01 N	1200° 27 W
Dante Alighieri II	Santa Barbara Island, SW shore of	1937	1938	11	Fish	Navigation	330° 27 N	1190° 02 W
Del Rio	Anacapa Island, 3 miles off light (Frencys Cove)	1935	1952	10	Fish	Fire	340° 00 N	1190° 24 W
Dora Bluhm	Santa Rosa Island, Southwest of Bee Rock	1883	1910	05	Lumber	Navigation	330° 57 N	1200° 12 W
G. W. Prescott	San Miguel Island, Point Bennett	1874	1879	08	Railroad ties	Navigation	340° 01 N	1200° 27 W
Goldenhorn	Santa Rosa Island, Southwest Side	1883	1892	09	Coal, bituminous	Northeast currents, 100 miles off course, "strong unknown currents"	330° 58 N	1200° 13 W
H T P Co IX	Santa Barbara Island, 4 miles off	1916	1921	01	Fish	Fire	330° 27 N	1190° 02 W
J. M. Colman	San Miguel Island, Point Bennett	1888	1905	09	Lumber	Navigational	340° 01 N	1200° 27 W
Jane L. Stanford	Santa Rosa Island, Skunk Pt.	1892	1929	08		Allision	330° 58 N	1190° 58 W
Kate and Anna	San Miguel Island, Cuyler Harbor	1879	1902	04	Sealing outfit	Anchor chain parted	340° 03 N	1200° 21 W
*Lady Christine**	San Miguel Island, North West End	1988	1997	11	None	Improper Lookout	340° 03 N	1200° 23 W
Legend	San Miguel Island, Point Bennett	1951	1967	08	None	Navigation	340° 01 N	1200° 27 W
Lotus	Anacapa Island, off	1901	1921	09	General	Fire	340° 00 N	1190° 11 W
Magic	Santa Rosa Island, Lake Anchorage?	1889	1899	08	None	Lost Mooring	330° 56 N	1190° 57 W
*Patria**	Santa Rosa Island, 1 mile north of East Point 100 yards off the beach, Skunk Point	1944	1954	06	Coal	Navigational error	330° 56 N	1190° 57 W
*Pectan**	San Miguel Island, Adams Cove	1902	1914	01	Ballast	Stormy	340° 01 N	1200° 26 W
Santa Cruz	Santa Cruz Island, Prisoners Harbor	1893	1960	12		Lost mooring	340° 01 N	1190° 41 W
Santa Rosa	San Miguel Island, Cuyler Harbor	1879	1899	11	Lumber	Heavy swell	340° 03 N	1200° 21 W
W T Co No. 3	San Miguel Island, Point Bennett	1922	1935	07	Film crew	Unseaworthy	340° 01 N	1200° 27 W
Wampas (aka Grey Ghost)	Santa Cruz Island, Valley Anchorage		1926	11	see comments		330° 59 N	1190° 39 W
Watson A. West	San Miguel Island, near Point Bennett	1901	1923	02	Lumber	Navigation	340° 01 N	1200° 27 W
Winfield Scott	Anacapa Island, Middle	1850	1853	12	Gold Bullion & Mail	Navigation In Fog	340° 01 N	1190° 23 W

*Not a total loss